

**IMPLICATIONS OF CLIMATE VARIABILITY AND CHANGE ON
URBAN ENVIRONMENTAL SECURITY:
A CASE STUDY OF LAGOS MEGA-CITY IN NIGERIA**

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DECLARATION

- 1) I, **Oluwole Olusegun Akiyode** (Student Number 219076946) hereby declare that this dissertation titled “Implications of Climate Variability and Change on Urban Environmental Security: A Case Study of Lagos Mega-City” is my unaided work.
- 2) All references, citations, and borrowed ideas in the thesis have been acknowledged accordingly.
- 3) I confirm that an external editor was not used for the thesis.
- 4) The thesis is being submitted for the degree of PhD in Geography in the College of Agriculture, Engineering and Sciences, University of KwaZulu-Natal, Durban, South Africa.
- 5) The PhD thesis has not been submitted previously for any degree or examination in any other university.



14/03/2024

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As the candidate’s Supervisor, I agree to the submission of this thesis.



14/03/2024

Professor Urmilla Bob (Supervisor)

Date

DEDICATION

To

Mary-Agnes Ibanga Akiyode
My covenant helpmate.

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ABSTRACT

The adverse ecological, political, socio-cultural, and economic consequences of climate variability and change have been documented by scientists in different parts of the world. Therefore, its implications on growing urban societies could affect stability and security in these locations. Thus, in the quest to support the closing of the capacity gaps and to enhance the body of knowledge in the emerging field of urban security in developing economy countries, this study examines the implications of climate variability on the urban environmental security of Lagos Mega-city in Nigeria. The study identifies the impacts of changing climate alongside rapid urbanisation on urban societies and is essential in promoting urban environmental sustainability that stimulates the process of encouraging climate adaptation and building resiliency in cities. The focus on vulnerability is vital given that the urban poor bear a disproportionate burden in dealing with climate variability and change associated with negative socio-economic impacts on livelihoods, infrastructure and basic services, and the natural resource base, especially in the context of limited resources and coping options. Adaptation strategies such as seeking alternate employment and livelihood opportunities, the sale of goods and services, leveraging remittances and external support, and accessing natural resources are undermined. Lagos Mega-city is a continuously growing city located on the coastline of the Atlantic Ocean. The city's location and rapid population growth make it susceptible to the impacts of changing climate. Subsequently, the study engaged a mixed methodological research design to achieve its objectives. This involved both qualitative and quantitative methods, encompassing exploratory and descriptive approaches. Primary data was collected by undertaking face-to-face interviews using the questionnaire that targeted adults in 400 households from the purposively chosen three communities in the Mega-city. The households were selected from spatial maps using Geographic Information System (GIS) tool and Geospatial Modelling Environment (GME). Other data were collected from three focus group discussions comprising community leaders and fishmongers. Also, information was retrieved through interviews conducted with six key informants who were mainly stakeholders in the government sectors in the city. The analysis of the data from the household interviews was done using the Statistical Package for Social Sciences (SPSS), while the qualitative data from the focus group discussions and key informant interviews were subjected to content analysis. The results and discussions emanating from the data analysis techniques employed were supported by relevant literature on the themes of the study. The study revealed widespread awareness of the issues concerning climate variability and change in the city due to the perceptions of the increasing variations in the intensity of rainfall, temperature, urban heat, level of flooding, and change in seasons in the city. However, there was negligible knowledge and understanding about what contributes to the increase in climate variability and change. Also, the study indicated that changing climate alongside rapid urbanisation features were perceived to be responsible for increasing biodiversity depletion and the enhancement of negative socio-economic impacts on the residents with implications on their livelihoods. Furthermore, the study showed that the communities in the city were engaged in diverse adaptation strategies to counter the impacts of climate variability and change. The study recommends sensitisation of residents on climate issues, initiation of effective urban governance, building climate-resilient infrastructures, and provision of climate variability and change policy as a sustainable urban environmental security approach essential for tackling changing climate issues in the city.

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LIST OF ABBREVIATIONS AND ACRONYMS

AAS	Australian Academy of Science
ADB	Asian Development Bank
BBC	British Broadcasting Corporation
CAN	Centre for Naval Analysis
CO₂	Carbon dioxide
DFID	Department of International Development
EM-Data	The Georeferenced Emergency Events Database
ETM +	Enhanced Thematic Mapper Plus
FAO	Food and Agriculture Organisation of the United Nations
FME	Federal Ministry of Environment
FRN	Federal Republic of Nigeria
GDP	Gross Domestic Product
GIS	Geographic Information System
GME	Geospatial Modelling Environment
GPR2C	Global Platform for the Right to the City
HSSREC	Humanities and Social Sciences Research Ethics Committee
IBM	International Business Machines Corporation
ILO	International Labour Organisation
IPCC	Intergovernmental Panel on Climate Change
ISSER/ EGC	Institute of Statistical, Social and Economic Research/ Economic Growth Centre
IUCN	International Union for Conservation of Nature
LBS	Lagos Bureau of Statistics
LDC	Local Development Centre
LGA	Local Government Area
LOSMOE	Lagos State Ministry of Environment
LST	Land Surface Temperature
LULC	Land Use Land Cover
MGD	million gallons per day
MPI	Multidimensional Poverty Index
NAS	National Academy of Science
NASA	National Aeronautics and Space Administration
NBS	National Bureau of Statistics
NDVI	Normalised Difference Vegetation Index
NERC	Natural Environmental Research Council
NGS	National Geographic Society
NGOs	Non-governmental organisations
NiMET	Nigeria Meteorological Agency
NLSS	Nigerian Living Standard Survey
NOAA	National Oceanic and Atmospheric Administration
NPC	National Population Commission
NRC	National Research Council
OECD	Organisation for Economic Cooperation and Development

OLI	Operational Land Imager
PAI	Population Action International
PPP	Purchasing Power Parity
SDGs	Sustainable Development Goals
SLF	Sustainable Livelihoods Framework
SPREP	South Pacific Regional Environmental Programme
SPSS	Statistical Package for Social Science
SULA	Sustainable Urban Livelihoods Approach
SULF	Sustainable Urban Livelihoods Framework
Km	Kilometre
Km²	Square Kilometre
TRS	The Royal Society
UHI	Urban heat island
UNDP	United Nations Development Programme
UNESCO	The United Nations Educational, Scientific and Cultural Organisation
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations International Children's Emergency Fund
UNODC	United Nations Office on Drugs and Crime
UN-Habitat	United Nations Human Settlements Programme
UN DESA	United Nations Department of Economic and Social Affairs
US	United States
USA	United States of America
USAID	United States Agency for International Development
USEPA	United States Environmental Protection Agency
WCMC	World Conservation Monitoring Centre
WEF	World Economic Forum
WMO	World Meteorological Organisation
WWF	World Wildlife Fund
%	Percentage
°C	Degree Celsius
°F	Degree Fahrenheit

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND INFORMATION

The security of urban areas is becoming a challenge in recent years in different parts of the world. This is not only because of the state of national security but also due to issues concerning global environmental change, which could affect urban stability and health, and distort its ecological services (Filho, Icaza, Neht, Klavins & Morgan, 2018; Mason, Shires, Arwood & Borst, 2017; Sikorsky, 2022). Thus, global environmental change has been linked to physical, socio-economic, human, and societal development (Loorbach & Wittmayer, 2015; Matsumoto, 2019; Mouratiadou, Biewald, Pehl, Bonsch & Baumstark, 2016; Ranasinghe, 2016; Shaikh & Saggu, 2022). Cities and urban areas will not only need protection from external and physical threats from aggression but will also require to preserve their ecological and environmental components from the threats of degradation, which could instigate instability, crisis, and insecurity. Hence, assessing the implications of climate variability and change on urban society in this period of global environmental challenges is paramount in developing policies and approaches that will enhance urban sustainability and development.

Due to increasing multifaceted urban challenges towards the end of the twentieth century, environmentalists, planners, and researchers have articulated and proposed different paradigms and approaches to ameliorating issues concerning urban development. This includes the enlargement of the concept of security through reclassification and embodiment of its coverage that heartens its sustainability (Adger et al., 2014; Barnett, 2003, 2007; Gemenne, Barnett, Adger & Dabelko, 2014; Kohli, 2018; Zdilar, 2023). Thus, the scope of state security was built up in recent times to include environmental security that focuses on the preservation and sustainability of the ecological components of the society to forestall impending crises and conflicts that may result from the inadequacy of indispensable environmental resources in the society (Adger et al., 2014; Barnett, 2007; Liu et al., 2022; Schilling et al., 2017; Manik, Sumertha & Widodo, 2023; Wu et al., 2020).

Schilling et al. (2017) and Zhang and Xu (2017) affirm that environmental security has a strong concern for the safety of the environment through a description of the health status of ecosystems and their capability to supply human beings and their surroundings its ecological services. Its assessment makes the current security discourse worldwide focus on the threat of external aggression to the state as in traditional security and the internal threats to individuals and their communities. Therefore, the threats to the environment and ecosystems are being considered by researchers and policy-makers in different parts of the world as part of the concept of security (Barnett, 2003; Barnett & Adger, 2007, 2018; Gverdtsiteli, 2023, Moarrab, Salehi, Amiri & Hovidi, 2021). The environmental security concept is developed as a foundational tool that will ensure the preservation of the environment from threats to the ecosystems and global ecological parameters. Gverdtsiteli (2023), Han, Liu and Wang (2015) and Spasov and Kastrati (2021) observed that it was formulated to encourage human dignity, environmental sustainability, and sustainable development.

The urban environmental security paradigm is a protégé of the environmental security concept that was developed to confine environmental security approaches to urban communities and cities but with national, regional, and global perspectives. Akiyode, Tumushabe and Abdu (2017) and Yang and Cai (2020) further maintain that the concept emphasises the sustainable management of urban landscapes and their ecological services for the present and future generations. Therefore, environmental security encourages the provision of urban communities' ecosystem services, supporting human and societal livelihoods with an emphasis on the interaction between environmental protection and economic development (Akiyode, 2010; Akiyode et al., 2017; Shao, Tian, Guan, Ju & Xie, 2013).

Urban environmental security is expected to enhance the socio-ecological integrity of an urban area or a city with the consciousness of its total security and sustainability. Consequently, it is an urban paradigm developed to encourage the city's environmental sustainability (Akiyode et al., 2017; Hodson & Marvin, 2009b). Polyakova and Gorina (2021) and Shao et al. (2013) further maintain that its assessment of a city alongside climate variability and change is essential in providing the basis for the city's planning and management. This will support and sustain the provision of nature capitals, encouraging the physical and mental health of cities' residents and, in

the end, heightens socio-ecological developments and encourages sustainable development (Akiyode et al., 2017; Li & Xu, 2010; Zhao, Zhou & Su, 2014; Zhao & Yang, 2007).

The concept of urban environmental security aligns with vision number 17 (Sustainable Cities and Communities) of the United Nations 2030 Sustainable Development Goals (SDGs). It embraces water security, food security, health security, livelihood security, adequate environmental management, justice, and equity; and encompasses all-inclusive management of the city through laudable sustainable urban policy.

1.2 RESEARCH PROBLEMS

Urban societies in different parts of the world are currently facing untold threats due to rapid and continuous urbanisation. The threats on urban societies due to rapid urbanisation are being compounded with the increasing and perceptible stress of climate variability and change in some cities around the world. Data from previous literature and reports affirmed the rapid and continuous urbanisation in many parts of the globe since around 1950 (Awumbila, 2017; Dano, Balogun, Abubakar & Aina, 2019; Echendu, Claver & Okafor, 2021; Liu & Zhou, 2021; United Nations, 2015; 2016b; 2018a). This urbanisation tendency, accompanied by the increasing population of cities, is at times indicated in its increasing economic growth but sometimes accompanied by negative environmental challenges and socio-ecological consequences (Grimm et al., 2008; McGranahan et al., 2005; Muhammed, Sabiu & Khalil, 2017; Parnell & Walawege, 2011; Taubenböck et al., 2012; Turok & Mcgranahan, 2020; Zhao et al., 2014). Therefore, cities are vulnerable to ecological, political, and socio-economic challenges (Cohen, 2019; Cornea, 2019; Loorbach & Wittmayer, 2015). The environmental and socio-ecological challenges that are faced by cities include the shortage and degradation of natural resources and the destabilisation of their ecosystems (Amberber, Argaw, Legese & Degefa, 2021; Gao, Zhang, He & Liu, 2017; Mohammed, 2019; Shao et al., 2013; Zhao et al., 2014).

Climate variability and change are, however, expected to increase pressures and threats on the city's infrastructures and ecological components, thus contributing to the negative ecological conditions from rapid urbanisation (Centre for Naval Analysis [CNA], 2014; Elias, 2018; Jaramillo

& Nazemi, 2017; Ojile, Koulibaqly & Ibe, 2017; Werrell & Femia, 2015). Therefore, changing climate alongside other pressures in the city may upset the functions and health of the ecosystem and the wide diversity of species within it (National Academy of Sciences/ The Royal Society [NAS/ TRS], 2019). Habibullah, Din, Tan and Zahid (2021) and Muluneh (2021) further maintain that ecosystems respond to changes in temperature and precipitation with implications for biodiversity. Some previous studies also suggest that the urbanisation processes contribute to the impacts of changing climate in cities through the transformation of traditional agrarian societies to modern urban communities, in so doing shaping their sensitivity and response capacity to extreme events (He, Zhou, Ma, & Wang, 2019). Thus, the alterations of the ecological conditions destabilise the social system with implications on the livelihoods of the citizenry (Ng, Lwin & Pang, 2017; Scheffran, Link & Schilling, 2012).

Lagos in Nigeria is a continuously growing city with a mega-city status. Although there is a dispute between the census data of the National Population Commission (NPC) of Nigeria and the one conducted by the Lagos State Government concerning the population of Lagos (Oke, Bokana & Shobande, 2017), specifically, the estimate of the population of Lagos given by the Lagos State government is higher than the population figure given by the NPC, there is no contest or disagreement about its rapid growth and mega-city status by the two institutions (Elias & Omojola, 2015; United Nations, 2016b; 2018a). The growth of Lagos was not anticipated by its urban planners and government, which made it overshoot its facilities (Atufu & Holt, 2018; Ayeni & Akiyode, 2013). Also, the rapid urbanisation alongside coastal development and urban land use regimes has led to the concentrations of people and businesses along its coast, which is low-lying and adjacent to the water environment (Ajibade, 2019). This has spurred the development of more than 100 slums in fragile and hazardous communities, sometimes along its coastline for mostly the poor migrants (Adelekan, 2010; Adegun, 2023; Ajibade & Mcbean, 2014; Gbadegesin, Heijden & Boelhouwer, 2016; Toesland, 2019). This is a major concern because of their propensity and susceptibility to the impacts of changing climate and climate extremes.

The Lagos coastline could be described as low-lying, precarious, and unsafe for its inhabitants (Danladi, Kore & Gül, 2017; Filho, Balogun, Ayal, Bethurem, Murambadoro, Mambo & Mugabe, 2018; Folorunsho, Salami, Ayinde & Gyuk, 2023). Equally, urban areas or cities like Lagos that are low-lying puts human population and economic capital at a threat of climate-related hazards,

which include sea-level rise and flooding from severe rainfall (Adewale, Fregene & Adelekan, 2017; Gasper, Blohm & Ruth, 2011; Jaramillo & Nazemi, 2017). Also, the informal coastal areas in Lagos, with their environmental fragilities and several household population sizes, generally more than 10 persons, have some of their houses built of temporary materials in locations that lack good drainage systems and neighbourhood infrastructure (Lawanson, 2016). Perceptively, the city population responds differently to the effects of climate extremes based on their socio-economic and individual factors (Ekoh, Teron & Ajibade, 2023; Reckien et al., 2017). Hence, the coastal communities in Lagos Mega-city are mostly occupied by the urban poor, who have been known to be highly vulnerable to negative implications of climate variability and change (Douglas et al., 2008; Elias, 2018; Kaoje & Ishiaku, 2017). However, the adaptive capacity to climate variability and climate change is very low in Lagos Mega-city because of poor urban governance, ill-maintained critical infrastructure, and weak institutions (Abiodun et al., 2017; Adelekan & Asiyambi, 2015; Elias & Omojola, 2015; Oladiti, Odunola & Alabi, 2018). Therefore, Lagos Mega-city in Nigeria is facing key urbanisation challenges that could be exacerbated by climate variability and change (Elias, 2018; Filho et al., 2018; Ilesanmi & Mgbemena, 2015; Jaramillo & Nazemi, 2017). Lagos Mega-city was chosen as the case study to analyse the impacts of climate variability and change on urban environmental security to address this lacuna in the research. Therefore, this study is one of the few that examines urban environmental security alongside climate variability and change implications.

1.3 SIGNIFICANCE OF THE STUDY

The significance of this study is to enhance knowledge and understanding that will boost the process of achieving urban security for city dwellers in light of climate variability and change. Therefore, it identifies the impacts of changing climate alongside rapid urbanisation on urban societies and is essential in promoting urban environmental sustainability that stimulates the process of encouraging climate adaptation and building resiliency in cities. The focus on vulnerability is vital given that they bear a disproportionate burden in dealing with climate variability and change, especially in the context of limited resources and coping options. Urban environmental security becomes a key issue for the majority of people living in vulnerable

communities. This is indispensable because urban and mega-urban centres in developing economy countries are one of the major parts of the world vulnerable to climate variability and change. This is due to the poor planning for the growing population commonly in developing economy countries that have led to the creation of haphazard structures in mostly fragile and risky areas of cities that also lack social facilities and amenities (Carius et al., 2018; Peters et al., 2018; Soyinka & Siu, 2018). Consequently, the levels of risk and vulnerability to changing climate are a function of the physical characteristics of the cities (Grasham, Korzenevica & Charles, 2019; Wheeler & Gober, 2015). This also depends on the socio-economic inequalities of the residents and governance (Adegun, 2023; Baker, 2012; Cohen, 2019; Leal et al., 2019). These urban socio-environmental components are functions of urban environmental security. Therefore, the analysis of climate change variability and change impacts alongside the urban environmental security paradigm will encourage holistic assessments of cities' ecological parameters alongside their socio-environmental factors, drawing on the Lagos Mega-city case study.

Presently, most of the research and published works on urban environmental security and its analysis radiate around issues and cases that are found outside the African continent, except for a few review articles relating the developing paradigm to the region (Akiyode et al., 2017; Gao et al., 2017; Han et al., 2015; Li & Xu, 2010; Liu et al., 2022; Liu et al., 2017; Liu, Huang, Wang, Luan & Ding, 2018). Therefore, analysing the concept of urban environmental security alongside climate variability and change in Lagos Mega-city will support closing the capacity gap, enhancing the body of knowledge, and spurring research on critical issues in African cities, countries, regions and the world at large. Subsequently, through its research findings, the study provides recommendations to enhance adaptation and mitigation of climate variability and change in vulnerable urban communities to the policy-makers and the city dwellers.

1.4 RESEARCH OBJECTIVES

The overall objective of the research is to assess the implications of climate variability and change on urban environmental security, using Lagos Mega-city as a case study. The research is guided by the following objectives:

- To identify the extent and the nature of climate variability and change impacts on urban environmental security of Lagos Mega-city in Nigeria.
- To examine the implications of climate variability and change in biodiversity depletion on the urban environmental security of Lagos Mega-city in Nigeria, focusing on aquatic livestock.
- To assess the implications of climate variability and change on households' livelihoods and well-being in Lagos Mega-city in Nigeria.
- To appraise the adaptation and coping abilities of the households and communities generally in Lagos Mega-city to the impacts of climate variability and change.
- To provide policy and programme recommendations based on research findings.

1.5 OVERVIEW OF THE THEORETICAL AND CONCEPTUAL FRAMEWORKS

This study utilises the political ecology theory and related concepts as a perspective in driving and contextualising the understanding and direction of the research with the aim of achieving the study objectives. The theories and concepts align with the process of achieving environmental sustainability that embraces the sustenance and preservation of human and environmental components. This is in line with urban political ecology principles of interrelating environmental forces with socio-economic and political forces in tackling and providing succour to the city and urban challenges (Benjaminsen & Svarstad, 2018; Kull, Sartre & Castro, 2015; Marks & Connel, 2023). Hence, the research focused and tailored its analytical procedures through the concepts of urban environmental security and sustainable urban livelihoods framework (SULF) to proffer ways to achieve urban climate security in Lagos Mega-city in the era of changing climate and climate variability.

1.6 OVERVIEW OF THE RESEARCH METHODOLOGY

A mixed methodology design was utilised in the study. This embraced both qualitative and quantitative approaches and encompassed descriptive and explorative approaches. Data and relevant information were collected from previous literature and reports, alongside physical observation and examination of the current scenarios about the Mega-city and related issues. This provided a veritable foundation for the study. Additionally, to achieve the aim and objectives of the study, three communities within the Mega-city were selected, where data and research information were collected using a prepared questionnaire to interview 400 household respondents selected using the random point sampling approach whereby adult household members at the homes at the points or the closest to the points selected were interviewed using the household questionnaire.

Furthermore, other supportive data came through purposively chosen focus group discussions and key informant interviews. Data emanating from the household questionnaire were subjected to statistical analysis, while the data from focus group discussions and key informant interviews were subjected to content analysis.

1.7 STRUCTURE OF THE THESIS

This study assesses the consequences of climate variability and change on the urban environmental security of Lagos Mega-city to examine the impacts of climate variability and change on the city's ecological resources as well as socio-environmental and economic parameters. To achieve the scope and focus of the thesis, it is organised into different chapters.

Chapter one functions as an introduction to the study. It presents the background information that provides relevant details that indicates the direction of the study. It also expounds on the research problems with an emphasis on the vulnerability of Lagos Mega-city to climate variability and change. It further explicates the significance of the study in analysing changing climate alongside the concept of urban environmental security for the study area. It further states the objectives of the study.

Chapter two presents the theoretical and conceptual frameworks that serve as the foundation for the study through the appraisals of the paradigms of security as environmental sustainability concepts in line with the study orientation and also expounds on the concept of sustainable urban livelihoods in relation to changing climate and its variability. It provides insight into the standpoints, directions, and activities to be undertaken in achieving the aims of the study.

Chapter three reviews previous literature on urbanisation and urban agglomeration in relationship to the growth of cities alongside climate variability and change with an emphasis on security concepts. It explores the concepts globally, narrowing down to regional and local issues with an emphasis on the case study. The chapter explores the implications of climate variability and change on cities focusing on the multiplications of the threats in the urban environment initiated by the population growth and deficiencies in urban planning in the global south using Lagos Mega-city as a case study. It identifies the perceptions of risks and consequences of changing climate by urban residents as a veritable key to building acceptable and sustainable climate policy alongside formulating adaptive and mitigation approaches delineated for the impact of climate variability and change. Also, this chapter investigates the complex power play in urban areas in line with the concept of the right to the city and highlights the inequalities that pervade cities. It surmises that the right to the city is indispensable in enhancing human security and also supports all-encompassing sustainable climate adaptations and mitigation processes for cities in this changing climate era.

Chapter four describes the approaches utilised in examining the implications of climate variability and change on urban environmental security using Lagos Mega-city as a case study. Thus, it expounds on the analytical procedures employed for the study and presents the research questions showing the approaches that were used to deliver the answers to the questions.

Chapter five undertakes the primary data analysis, unveiling the city's demographic, socio-economic, and socio-livelihood attributes in line with the impacts of climate variability and change. It analyses the extent of the awareness of the changing climate through perceptions of the household respondents, participants of focus group discussions, and the key informant interviewees. It also examines the data retrieved on the impacts of climate variability and change on urban environmental security in the city, focusing on water security, biodiversity, and

livelihoods. Furthermore, the chapter reveals the adaptation strategies engaged by the communities in the city against the implications of climate variability and change.

Chapter Six recapitulates the results obtained in the survey conducted in line with literature analysis providing recommendations that will encourage urban environmental security of the city in this changing climate and variability era. Hence, it presents the summary, recommendations, and conclusion of the study.

1.8 CONCLUSION

This chapter introduces the thesis through an exploration of the implications of climate variability and change phenomena alongside urban environmental security using Lagos Mega-city as a case study. Thus, it recognises that the changing climate issue has been a contemporary challenge being faced in different parts of the world in this era. It acknowledges that the implications of climate variability and change are expected to be pronounced in cities where most of the human population is currently residing.

Lagos Mega-city is a continuously growing city that is agglomerating speedily and is attractive to migrants because of its industrialisation, administrative, commercialisation, and economic status. Also, it identifies that its proximity to the coast of the Atlantic Ocean alongside other water environments, which includes a large mass of Lagos lagoon that interfaces with land, where communities are concentrated that predisposes the city to the impacts of climate variability and change with effects on biodiversity, ecosystems, and environments with implications on the residents and urban environmental security. Therefore, this chapter stands as the introductory and foundational base for the thesis to assess the implications of climate variability and change on urban environmental security in Lagos Mega-city in Nigeria to encourage adaptation strategies and build resilience.

CHAPTER TWO

THEORETICAL AND CONCEPTUAL FRAMEWORK

2.1 INTRODUCTION

The continuous change in climate, alongside its variability in different parts of the world, is an obvious global environmental phenomenon that became an object of analysis by scientists and policy-makers in the last century. This was mainly due to its noticeable impacts and unavoidable implications in different parts of the universe. This made climate security discourse a growing debate in the literature and contemporary global politics towards the end of the 20th century (Dellmuth et al., 2018; Lamain, 2022; Mcdonald, 2013). There is a general consensus, as highlighted in the previous chapter, that climate variability and changing climate pose a threat to human security and sustainable development.

Urban settings provide opportunities for the achievement of the unending progress towards the three dimensions (social, economic and environmental) of sustainability (Marzouki, Chouikh & Mellouli, 2021; Mcgranahan & Satterthwaite, 2014). Subsequently, urban environments and cities worldwide are some of the foremost places where the effects of the changing climate and its variability are expected to be expressed with diverse implications on the dwellers, urban infrastructure and biodiversity. The urban environment also shapes capacity, enhances cohesive responses and increases sensitivity to climate variability and change (Garschagen & Romero-lankao, 2015; Mehryar, Sasson & Surminski, 2022; UN-Habitat, 2011) since they have the greatest resource base that will mitigate risk as well as prepare for and recover from extreme events (Kerle & Müller, 2013). This is mostly through the design, development and implementation of diverse concepts and sustainable policies that are envisaged to enhance the amelioration, mitigation and adaptation of the effects of climate variability and change. Hence, the effectual management of the increasing effects of climate variability and change is indispensable in the achievement of sustainable security and development in urban settings.

This chapter examines the theoretical and conceptual frameworks underpinning the study. This is on the basis that the theoretical framework is a logical arrangement of various theories expected to demonstrate the relationship between the phenomena or multiple variables to be examined, and

the conceptual framework proposes the relationship of concepts to one another in the study (Chowdhury, 2019). Thus, the theoretical and conceptual frameworks provide the understanding of the perspectives, directions and actions undertaken in the achievement of the aim and objectives of the study.

This chapter examines the theoretical and conceptual frameworks that support and grant insights into the implications of climate variability and change on urban environmental security in Lagos Mega-city in Nigeria. It uses the concept of political ecology as a foundational base to guide the analysis of the paradigm of urban environmental security alongside urban livelihoods. Figure 2.1 depicts the underpinning frameworks of urban environmental security and sustainable urban livelihoods resting on the concept of political ecology.

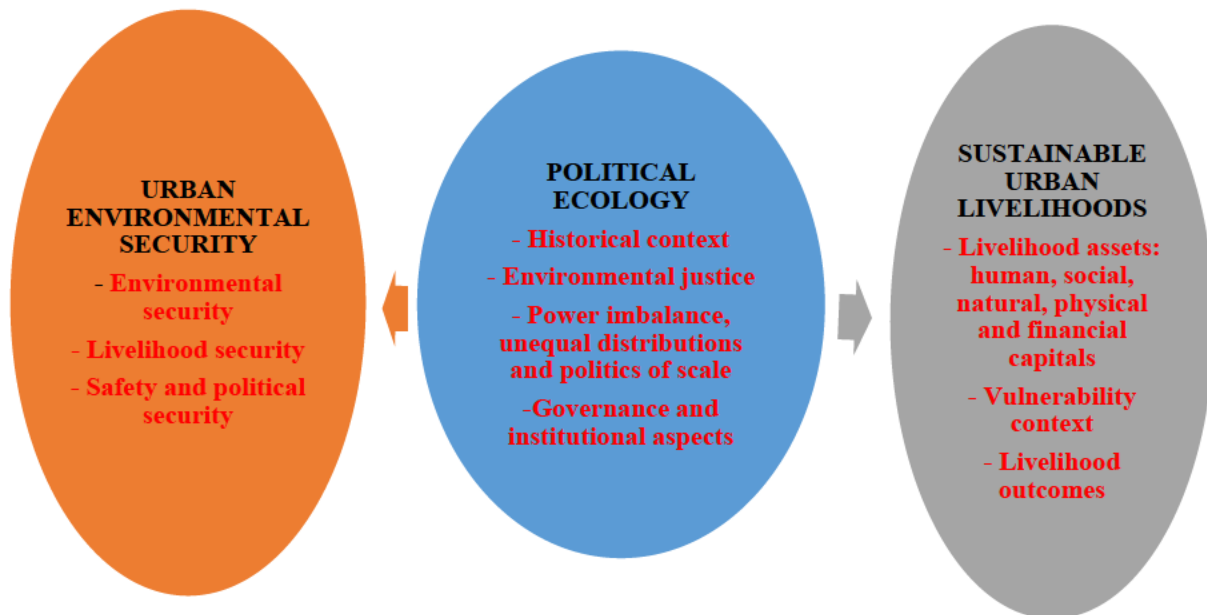


Figure 2.1: The underpinning frameworks for the study

This study acknowledges the underpinning theories through the analysis of political ecology as an environmental sustainability concept and also appraises and explores the security paradigm alongside sustainable urban livelihoods. This study also affirms that the political ecology concept is an environmental sustainability concept that analysis and revolves around history/ culture, governance instruments, environmental justice, formal and informal institutions, unequal distributions of costs and benefits, politics of scale and power imbalance in bid to support human security through the maintenance of livelihood security, environmental security and political security (Schilling, Schilling-Vacaflor, Flemmer & Froese, 2021). Figure 2.2 below describes political ecology graphically as a security concept with a multi-scaler political ecology perspective with a view of the interaction of power asymmetries facilitating the delivery of pros and cons across players and systems.

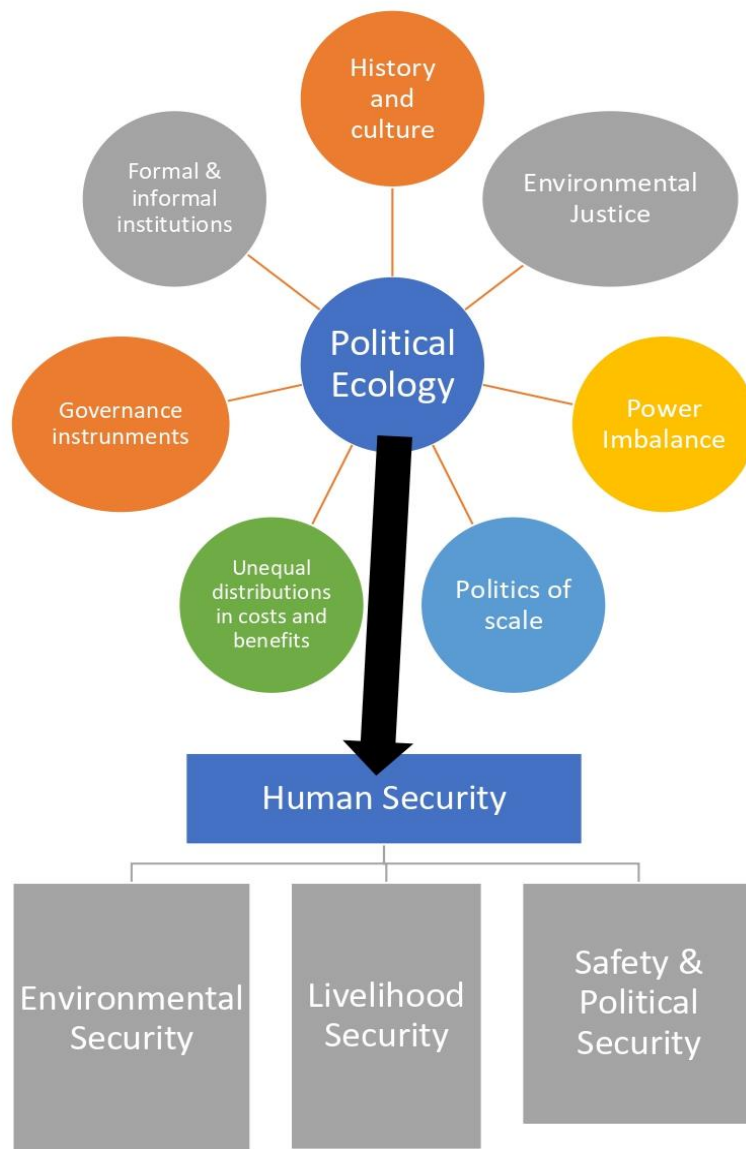


Figure 2.2: Political ecology as a security concept (adapted from Schilling et al., 2021: 2)

2.2 POLITICAL ECOLOGY PERSPECTIVE OF ENVIRONMENTAL SUSTAINABILITY

Political ecology is a diversity of theoretical and procedural approaches to socio-ecological relations that share common interests in questions that are related to resource management; environmental knowledge, access and control; and their effects on livelihoods alongside the dynamics of environmental change (Bassett & Peimer, 2015; Purwins, 2020). However, the definitions of political ecology abound and are not exclusively consistent with a tendency to become broader and ambiguous (Tetreault, 2017). The definition of political ecology by two geographers, Harold Brookfield and Piers Blaikie, in 1987, linked the concept to a political economy approach and attitude towards environmental degradation, creating a foundation for complex socio-economic and political interactions that embedded environmental change (Billon & Duffy, 2018; Neumann, 2009).

Political ecology focuses on power relations in environmental studies in the previous decades (Benjaminsen & Svarstad, 2018; Marks & Connel, 2023). It analyses the injustice and power relations on issues about resources and the environment (Billon & Duffy, 2018; Purwins, 2020). Thus, it interconnects the fundamentals of political forces with ecological dynamics (Osborne et al., 2021; Scoones, 2009). Hence, Osborne et al. (2021), in a review of issues of environmental restoration, found that ecosystem or environmental degradation is powerfully driven and influenced by political and economic relations that could lead to local resistance, environmental conflicts, and struggles for the control and access of resources. Svarstad and Benjaminsen (2018) argue that power may be used by actors differently since power is professed as a force that may be used by people without accountability and consciousness. The authors further reiterate that power is exercised by two categories of actors, principally those involved in environmental intentions and those resisting them.

At the inception of the political ecology concept, it focused principally on control of renewable resources mostly in the rural global south but has expanded to industrialised countries in the global north and urban areas, also embracing non-renewable resources (Benjaminsen & Svarstad, 2018). Furthermore, a crucial approach in early political ecology was the evaluation of development initiatives from the bottom up and emphasising the importance of indigenous and local knowledge

about the environment (Miller & McGregor, 2020; Neumann, 2009). Though it has grown to include a range of diverse topics, theories and sites, it still holds on to its focus on power in human-environment relations (Fajarudin, Abdoellah, Djuyandi & Sumadinata, 2022; Galeana, 2023; Lawhon, Ernstson & Silver, 2014; Robbins, 2012).

Political ecology has expanded further than rural areas into a new research context focusing on contemporary urbanisation alongside socio-environmental issues (Gandy, 2022; Miller & McGregor, 2020; Neumann, 2009). The goal of urban political ecology is to analyse and examine the processes and material flows that shape the city; thus it is apprehensive about the procedures of urbanisation (particularly impacts on nature or ecosystems) as well as the cultural, social and political interactions through which biophysical and material entities become distorted in the making of most unequal cities (Gandy, 2022; Lawhon et al., 2014). Therefore, political ecology could be regarded as a framework that focuses on urban environmental sustainability and security, including inclusivity and well-being.

Political ecology has a connection with climate variability and change, interrelating it to socio-economic and political forces in society. Therefore, taking the perspective of political ecology in a study is an attitude of research that discusses the nature-society phenomena by giving attention not only to ecology but also to the notion and the actions of socio-economic aspects alongside the wider political economy that includes indirect power that affects all levels of society (Benjaminsen & Svarstad, 2018; Kull, Sartre & Castro, 2015).

Political ecology led to the creation of environmental security thinking and assessment (Duffy, 2022; Neumann, 2009). Environmental security is described by Schilling, Schilling-Vacaflor, Flemmer & Froese (2021: 2) through the research of Vivekananda et al. (2014) as the absence of threats or risks to the immediate environment where a community and/ or a person resides and depends on. The environmental security concept is a forerunner of urban environmental security. Environmental security is perceived as concerning on both sides of the political ecology divide since it creates anxiety through the thesis of resource wars through advocating and signifying militarising of the environment, but its relevance is indispensable in making the environment secure for people and its biodiversity (Hough, 2019). However, urban environmental security that is its protégé focuses steadily on urban sustainability. Also, political ecology has sought to analyse

the power relations engaged in managing the ecological base of current landscapes and livelihoods (Marzelius & Droste, 2022; Taylor, 2014). Therefore, livelihood assessments have always been a part of political economy's wider intellectual piece (Ayilu, Fabinyi, Barclay & Bawa, 2023; Scoones, 2015).

2.3 THE SECURITY PARADIGM AS AN ENVIRONMENTAL SUSTAINABILITY CONCEPT

There was a need to reconceive and review the concept of security and what may constitute conventional or traditional security around the turn of the century by scholars and policy-makers (Aguirre, 2008; Ahluwalia, 2020; Tschirgi, 2005). This is because traditional security is more connected to nation-states than people (Kohli, 2018). Also, the security concept has been criticised for its narrowness and modelling on the logic of military security and the neglect of routine procedures that could amount to security policies (Diez, Lucke & Wellmann, 2016).

Consequently, the appraisal of the security paradigm began after the cold war in the 1980s between the then Soviet Union (Union of Soviet Socialist Republics) and USA (Biswas, 2011; Dalby, 2002; Hakala, Lähde, Majava, Toivanen & Vad, 2019; Manik et al., 2023). Since then, the security paradigm started shifting from its initial nation-state or conventional and traditional emphasis on the protection and preservation of the society or state from stresses, threats, and risk of physical and external aggression through the military to individuals with the community's focus (Ahluwalia, 2020; Anasenko, Zholudeva & Melnichenko, 2020; Koff & Maganda, 2016). Security has become broadened and enlarged than its conventional and traditional form with new classifications that support the protection of society from the threats, risks and stresses on the ecological and environmental parameters in our communities that may lead to insecurity (Akiyode, 2013; Akiyode et al., 2017; Altunkaya, 2021; Koff, 2016; Koff & Maganda, 2016, Zdilar, 2023). It supports sustainable practices that will encourage global environmental benefits that are essential in the maintenance of the societal ecosystems useful in the generation of food, clean water and air (Ratner, 2018).

Environmental security is one of the newly emerged forms of security at the turn of the 21st century that is developed as an addition to conventional security but with a primary focus on the preservation and sustainability of the ecological components of society. Environmental security is closely associated with environmental degradation, with implications for the well-being of human beings and all the living and non-living components of society (Ahluwalia, 2020, Gverdtsiteli, 2023).

The environment became one of the world's major themes that was increasingly receiving global attention with intense political debates on its protection and preservation based on its transnational nature towards the turn of the 20th century (Kohli, 2018; Trombetta, 2008). Thus, the idea of attaching the environment to the security concept as environmental security assists the environmental community in raising awareness of environmental issues among political leaders and the public, making environmental challenges visible as significant security concerns (Page, 2010; Polyakova & Gorina, 2021).

Environmental security was, therefore, established on the premise that environmental threats that destabilise the community and its ecological elements may, in the long run, generate crises or insecurity in societies, which may have adverse effects on the stability of the state (Akiyode, 2013; Marcel, 2006; Ślusarczyk, 2021). It depicts the state of the ecosystem and the environment of a place (Liu et al., 2017). It refers to how national or human security may be threatened by environmental change or how the environment can be made insecure (Hough, 2019). Therefore, some of the major focuses of the concept include threats to societal health, livelihood security and vulnerability analysis (Kohli, 2018; Maltais, Dow & Persson, 2003). Hence, in its earlier developmental phase, the definition of environmental security was streamlined to issues of environmental degradation and threats that may drive social unrest and conflicts (Koff, 2016; Koff & Maganda, 2016; Manik et al., 2023). Such include describing environmental security as a process expressed to minimise environmental or ecosystem damage with a notion that economic vulnerability and resource dependency play significant roles and connections between environmental change and potential crises and conflicts (Dalby, 2013b; Pachauri & Benedick, 2000; Ślusarczyk, 2021). It creates an elaborate relationship between the contemporary global environmental changes in the world alongside its environmental threats and cooperation with the

sole aim of utilising cooperation to minimise vulnerability that is caused by environmental threats and degradation (Dwivedi, 2018).

The previous studies were centred on two main features, one focusing on human security and the other concentrating on conflict (Hakala et al., 2019). Hence, as a contemporary and ongoing developmental concept, researchers and policy-makers have not yet had a consensus definition for environmental security. Most of the recent descriptions of the security paradigm are now technically becoming silent about the wars and crises of the state (except in a few cases) as it was emphasised at the inception of the paradigm but instead focuses more on issues that pertain to societal environmental sustainability. Therefore, the concept provides an opportunity to pursue substantial threats and provides a solution that will embrace the principles of sustainable development (Maltais et al., 2003; Spring, 2020).

Given the above context, environmental security or ecological security has also been described as a process that guards against environmental degradation by preserving and protecting humans, natural resources and materials stretching from the local to global levels (Belluck, Hull, Benjamin, Alcorn & Linkov, 2006; Zikargae, 2021). It reflects the degree of ecosystem health and integrity for every society (Chen, 2017; Chen et al., 2018; Liu et al., 2022). Equally, the issues of environmental degradation, climate change, and preservation of environmental integrity are the backbones of its conceptualisation and are integral to all its definitions (Akiyode, 2013; Ayeni & Akiyode, 2013; Belluck et al., 2006; Biswas, 2011; Chen, 2017; Chen et al., 2018; Marcel, 2006; Ślusarczyk, 2021). Thus, a workable and suitable definition for environmental security radiating from the literature makes it a process that is expected to maintain the integrity of ecosystem functions and structures in order to protect and promote biodiversity in the face of societal threats (Jiang et al., 2021; Liu et al., 2022; Zhou, Lin, Ma, Qi & Yan, 2021). Consequently, the concept of environmental security or ecological security is a sustainable development paradigm formulated to encourage human dignity through sustainable management of the immediate environment. This perception rests on the principle that issues about the environment in a society or a state can threaten the internal security of the community or the state (Biswas, 2011; Fagboun, 2011; Kohli, 2018; Liu et al., 2022). Therefore, when a society aligns with the principles of environmental security, there will be the encouragement and the prevention or minimisation of human-induced changes to the environment that will avert adverse implications of environmental challenges for

the present and future generations (Kreimer, Arnold & Carlin, 2003; Pachauri & Benedick, 2000; Polyakova & Gorina, 2021; Zhang & Xu, 2017).

Climate security is a prime component of environmental security. Climate security is essential because of the emergence of the threats of changing climate that is becoming obvious in most parts of the world with effects on natural resources that may endanger state security (Barnett, 2003, 2007; Barnett & Adger, 2007; Marcel, 2006; Shaikh & Saggu, 2022; Sikorsky, 2022). Therefore, every nation is expected to perceive climate security as vital and existential since it is anticipated to determine the focus of international security (Mabey, 2008; Shaikh & Saggu, 2022). Changing climate impacts may intensify the stress and threats in a rapidly growing city, mostly in developing nations, because of inadequacy in planning towards unexpected urbanisation (Akiyode et al., 2017).

Environmental security is projected to embrace the effectiveness in the management of every environmental good, parameter and resource to bring about human security and sustainable development, which will drive peace and security in society. Nevertheless, issues of growth and development of cities and urban society are intertwined with security which could be influenced by changing climate and climate variations (Hodson & Marvin, 2009b; Polyakova & Gorina, 2021; Tschirgi, 2005). Thus, the development of the environmental security paradigm as one of the new security additions is intended to encourage environmental integrity, health, growth, societal stability and sustainability in urban societies.

2.4 HUMAN SECURITY AND ENVIRONMENTAL SECURITY NEXUS

Human security is a general view of all threats to human existence, dignity and life, and stresses the need to respond to such threats (Ani & Anyika, 2023; Ferris, 2020; Neethling, 2005). Thus, it protects human core values, enhancing its fulfilments and freedoms (Balogun, Weru & Shen, 2023, Suleiman, 2022; UN-Habitat, 2007). It takes the discussions of security from the issue of the nation-state to human beings as the possible victims outside physical violence as the only relevant threat and beyond physical damage as the only relevant harm (Ani & Anyika, 2023; Gasper, 2006; 2010; Manik et al., 2023). Thus, it looks at the security of people's livelihoods (Gómez & Gasper,

2013; Kohli, 2018). Urban societies and cities in this changing climate era are presently inhabiting the highest human concentrations in the world with the tendency to create stress on people's livelihoods, values and dignity.

Human security is a situation where societies can manage stresses in relation to their needs, rights and values with an emphasis on the welfare of ordinary people (Alkire, 2003; Paris, 2001; Poem, 2021). It focuses on basic needs aimed at securing humanity (Gasper, 2006; Spasov & Kastrati, 2021). The 1994 United Nations Development Programme (UNDP) report highlighted economic security, food security, environmental security, personal security, community security and political security as components of human security (Ani & Anyika, 2023; Morrissey, 2019; Svensson, 2007). It naturally connects several kinds of freedoms, such as freedom from want and freedom from fear as well as the freedom to take action on one's behalf (Commission on Human Security, 2003; Khagram & Ali, 2006; Satoh, 2021).

The sub-divisions of human security link it to every part of human society, making it a fundamental principle behind sustainable living. Thus, conventional security is expected to be dependent on human security, where the latter complements national security by protecting people from a range of menaces (Commission on Human Security, 2003; Crabtree, 2020; Gasper & Gomez, 2023). Human security explores the interactions between society and global environmental change in various societal and geographic contexts by examining the direct threats caused by the interaction between access to natural resources, threatened livelihoods and the environment (Hakala et al., 2019). Thus, it is related to environmental preservation (water, ecosystems and biodiversity), socio-economic stability and sustainable development (Ferris, 2020; Ganoulis, 2004). Hence, water security has a connecting link to all the sub-divisions of human security because of its significance to the sustenance of life. Human security is indispensable to environmental security and sustainability, making it a vital ingredient for the sustenance of environmental integrity and sustainability.

A society's level of environmental security may determine the state of its human security. Thus, it supports the possibility of peaceful co-existence and socio-economic development because it is an all-encompassing concept touching every critical facet of life. Therefore, the encouragement of the achievements of human security and its tenets in any society will promote societal

sustainability, development, security and peace. This supports human survival, life and dignity (Liu et al., 2022; Neethling, 2005).

Rapid urbanisation engenders significant urban challenges for human security in the context of global environmental change, which includes changing climate that relates to overall ecological footprints, maintaining infrastructural and institutional integrity, and preserving shelter and livelihoods (Simon & Leck, 2010). Consequently, unsustainable management of the environmental goods and resources in society will affect environmental security, having a corresponding effect on human security.

2.4.1 Urban environmental security as an environmental sustainability concept

Urban security has been part of urban development since ancient cities were always building a wall around the city as a defence against invaders (Ljungkvist, 2020). Urban security is traditionally perceived in the context of crime prevention and physical protection that encourages the safety of its residents (Little, 2004; Tulumello, 2018). Hence, having a liveable urban environment rests mostly on urban security because urban residents will only be satisfied in the city if there is a sense of safety of life and property (Zhan, Kwan, Zhang, Fan & Yu, 2018).

Urban insecurity issues are far beyond terror and war, especially with increasing global risks tied to urban life, including ecological challenges such as changing climate, which makes reaching a consensus definition for urban security difficult, particularly in identifying the threats to be included in the concept becoming awkward and sometimes politicised and normative (Ljungkvist, 2020). Thus, urban security is now becoming a political and policy issue in many countries, mostly in Europe, because of social issues that include life quality with the intent of proactive prevention rather than reactive detection (Grimaldi, Coppola & Fasolino, 2023; Kübler & Maillard, 2020).

Urban security could be linked exclusively to social challenges and public order issues, and with a relationship between organisation, structure and the ways spaces in the city are used (Bolici & Gambaro, 2020). Thus, there is a relationship between urban space and urban security, making the design of public spaces to play an important role in the perception of fear and insecurity (Filippi,

Cocina & Martinuzzi, 2020). Notably, about 90% of the urban areas in different parts of the world are located on the coastline, making them susceptible to sea level rise and extreme events that distort their urban security (Ljungkvist, 2020). Therefore, it is desirable to include urban environmental security in the management of urban security to enhance the city's environmental integrity. This is because a sharp change in structure that is witnessed by a rapidly growing city weakens the eco-services functions that are expected to be provided through urban ecological infrastructure (Li & Xu, 2010; Yang & Cai, 2020). Eco-service functions in every society and city are indispensable ingredients in developing adaptation strategies among urban residents to cope with changing climate.

As noted earlier, urban environmental security is a sub-set of environmental security framed to enhance urban environmental sustainability but with national, regional and global perspectives. The concept of urban environmental security is also referred to as urban ecological security (Akiyode et al., 2017; Kornec, 2020; Li & Xu, 2010; Shao et al., 2013; Yang, Li, Zhu, Dong & Xu, 2022; Zhao et al., 2014; Zhao & Yang, 2007). It is framed to safeguard the ecological system of cities that, at most times, are fragile (Akiyode et al., 2017; Gao et al., 2017; Yuan, Bai, Zhang & Zu, 2022). It is a spatial concept with the opportunity for variation tendencies to guarantee a multifaceted system of humans and the environment in a city by preventing potential risks from human and natural activities to humans and its environmental space (Shao et al., 2013). Urban environmental security is concerned with the stability, services and resilience of the urban ecosystem in the context of the ecology in the area (Zhao & Yang, 2007; Yang, Li, Zhu, Dong & Dong, 2022).

There has been no consensus in relation to the definition of urban environmental security like other newly developed forms of security paradigms by academia and policy-makers (Han et al., 2015). Nevertheless, most urban environmental security definitions by policy-makers and academia emphasise the sustainable management of urban landscapes and their ecological services for present and future generations (Akiyode et al., 2017; Li & Xu, 2010). Akiyode et al. (2017) describe urban environmental security as the process of focusing on the preservation and conservation of urban landscapes alongside their ecological services for the upcoming generations. Ghosh, Chatterjee and Dinda (2021) define the concept as a process of measuring the extent of urbanisation pressure alongside the degree of ecological sensitivity. Urban environmental security

focuses on the natural and socio-economic factors of a city, concentrating on interactions between environmental protection and economic growth (Li, Zhou & Yi, 2022; Shao et al., 2013). Thus, it ensures the provision of sustainable ecological services in cities and urban communities to boost the total well-being of urban dwellers (Akiyode, 2010; 2011; Kornec, 2020).

Urban environmental security involves the practice of integrating urban landscapes to provide enough ecological services that are expected to encourage the development of socio-economic systems that support sustainable development (Ghosh et al., 2021; Li & Xu, 2010). It assesses the levels of threats to immediate human society and its nature capital in urban settings (Akiyode et al., 2017). Therefore, urban environmental security can be defined as the assurance of protection against threats to the mental and physical health of urban residents, including life support systems and urban, social and economic sustainable development (Liu et al., 2022; Zhao & Yang, 2007). It could also be regarded as the preservation of the natural urban capital, which includes its resources and the maintenance of the usual survival and developmental standing of the human living environment (Wu et al., 2020).

The need for urban environmental security in cities cannot be overemphasised since it ameliorates the environmental challenges that result from cities' continuous rapid urbanisation in this changing climate era. This is in the context that cities are often faced with rapid population growth, environmental pollution, natural resource shortage and ecological destabilisation, which may create environmental crises (Spasov & Kastrati, 2021; Zhao et al., 2014). Also, cities with their concentrations of population are becoming victims of resource constraints in the light of changing climate, requiring the principles of urban environmental security in the development of strategies that will reconfigure them and their infrastructure in ways that will safeguard the flow of resources and assist its ecological and material reproduction (Hodson & Marvin, 2009b; Wang & Pan, 2019). Hence, to assess and proffer solutions to the negative consequences attributed to urban growth in the era of climate variability and change is the development of the concept of urban environmental security. This paradigm is formulated to encourage human development and environmental sustainability in cities and urban settings (Akiyode et al., 2017; Liu et al., 2022; Polyakova & Gorina, 2021).

2.4.2 Climate security as an environmental sustainability concept

The term climate security has varied definitions that radiate around issues concerning the impacts of changing climate and processes of amelioration, adaptation and mitigation of climate impacts and its connection to many policy areas (Dellmuth et al., 2018; Phillis, Chairetis, Grigoroudis & Kanellos, 2018; Nevitt, 2023). Remmits, Dick and Rademaker (2021) define climate security as the relationship between human security, national security and changing climate through the indirect and direct threats to security caused by changing climate-related natural hazards. Kool and Birkman (2021) define climate security as the interaction between change experienced in local, regional or global patterns; economic, political, military and social stress/ risks; and security, peace and stability. Phillis et al. (2018) define climate security as the assessment of the changing climate impacts and risks on the culture, stability and livelihoods of a community and its individuals. Climate security could be regarded as a situation when the states, communities and people have the ability to manage stresses and threats that emerge from changing climate and climate variability (Dellmuth et al., 2018; Mirumachi, Sawas & Workman, 2019).

Climate security is a contemporary discourse that focuses on the threats that climate variability and change pose to the security of the state (McDonald, 2013; Phillis et al., 2018). Hence, the paradigm is developed because of the increasing climate and weather extremes in different parts of the world (Smith, Mobjörk, Krampe & Eklöv 2019). Climate security is developed to respond to common ecological challenges or risks to the environment and human security (Lamain, 2022; Scheffran, Link & Schilling, 2009; Spasov & Kastrati, 2021). Climate security is indispensable to human and environmental sustainability, which makes it crucial to sustainable development and environmental security.

Climate risk is potentially an existential threat but, when invoked, could correspond to security threats that are direct and urgent, which has resulted in the securitisation of climate issues (Diez et al., 2016). This is on the premise that environmental challenges are considered low politics (issues that are social, cultural and economic) rather than high politics (issues that are indispensable to the existence of the state), as in security issues whose logic is fixed and not flexible (Trombetta, 2008). However, Lucke, Wellmann and Diez (2017) assert that the Copenhagen School of Security Studies argue that no identifiable emergency measures are taken in the field of environmental

security at present, which may support its securitisation. Critics of climate security, on the other hand, state that the use of the term may complicate the significant tones of some climate-related hazards (Kameyama & Ono, 2021).

Hence, there have been multiple ways of approaching the relationship between changing climate and security, which have implications on the concept of climate security both positively and negatively, raising questions about the ethical, political and analytical choices made around it (McDonald, 2018). However, examining the changing climate through the lens of the security concept enhances its identification as an important issue whose debate and discourse are essential for the state and society (Hayes & Knox-Hayes, 2014; Silke & Morrison, 2022).

The discussion of the concept is widespread, but it is still progressive and contested and has not been fully translated into policies that are generally seen as appropriate and necessary on a global scale (Diez et al., 2016; Kameyama & Ono, 2021). Climate security has propelled environmental security issues as a process of orienting security around human well-being (McDonald, 2013, 2018). Thus, it could be seen as an environmental security concept with the heart of human security since its referent object is the individual and communities that the direct implications of changing climate have on their daily lives rather than on violent conflict and state security (Diez et al., 2016; Lucke et al., 2017).

World bodies, including the United Nations, European Union and African Union, international governmental organisations and scientists, have entertained and supported climate security discourse in their discussions. For example, the United Nations in 2018 created a climate security mechanism as a way of strengthening the capacity of the United Nations to address climate-related security issues and emergencies (United Nations, 2021). Also, climate security is now implicitly or explicitly recognised by the African Union Assembly with the development of programmes and initiatives that are not yet implemented (Aminga & Krampe, 2020). Some states have also recognised the threats of changing climate in their released national security strategies (McDonald, 2018). The cause of the civil war that occurred in Darfur, for example, was controversially declared by the former United Nations Secretary-General Ban Ki-Moon and some policy-makers and academia as an issue instigated by changing climate (Busby, Smith & Krishnan, 2014; Mazo, 2010).

Climate security is an academic, political and policy discourse designed to explore the security implications of climate variability and change on the environment (Telford, 2018; Wellmann, 2014). It is a process of emphasising the importance of the linkage of climate science to security to press for the geopolitics that will speed up adaptation and mitigation actions (Dalby, 2013a; United Nations, 2021). Hence, the discourse encourages the engagement of society as part of the environmental change discussions to provoke sustainable policies (Dalby, 2014; Dellmuth et al., 2018; McDonald, 2018). Moreover, it embraces the discussion of human security that puts the vulnerable, poor and marginal victims of political and environmental disruptions in the focus of analysis by the technocrats to speed up processes of ameliorating the effects of climate variability and change (Dalby, 2013a; Froese & Schilling 2019; Thomas & Warner, 2019). However, the significance of policies to promote climate security could ultimately be measured by their capacity to bring about results in regions most affected by changing climate-related forms of security risks (United Nations, 2021).

Climate security is now an indispensable global issue, especially when climate-related events have left no region in the world unaffected, shaking national economies, stressing state budgets, destroying infrastructure, and undermining livelihoods (Smith et al., 2019). Therefore, climate variability and change are one of the stressors that affect the dynamics of livelihoods in cities making the poor who face multiple deprivations slip into chronic poverty or worsening their existing poverty as a result of climate extremes or events, thus triggering fresh vulnerabilities and some opportunities for communities and individuals (Olsson et al., 2014).

The need for urban climate security cannot be overemphasised. Urban climate security is expected to seek and prioritise environmental sustainability in cities in the presence of a globally changing climate. This is because there is present evidence of changing climate instigating challenges that include water insecurity, food insecurity, livelihood insecurity and health insecurity (Behnassi, 2017). Therefore, urban climate security seeks a condition when city residents possess the knowledge and capacity to manage the problems that are associated with the threats of climate variability and change (Dellmuth et al., 2018). Thus, it targets human security in cities and analyses the effects of changing climate on human livelihoods to support the security of the state and forestalling future conflicts (Diez et al., 2016; Lucke et al., 2017). It radiates around several

policies, including diplomacy, development, security, migration, peace, conflict and disaster risk reduction (Dellmuth et al., 2018).

2.5 SUSTAINABLE URBAN LIVELIHOODS

The imminent and inevitable climate variability and change globally have been known to influence the intensity of extreme events in many vulnerable cities worldwide. For example, in most cities in developing countries, their facilities are overstretched with increasing urbanisation that accompanies their fragile typology making their environment to be vulnerable to extreme events from changing climate (Revi et al., 2014; Sterzel et al., 2020). Extremes events that are associated with changing climate may increase vulnerability and undermine households' impending earnings and livelihood strategies, leading to an increase in the need to reduce risks (Kaczan & Orgill-Meyer, 2019). Consequently, the tendency of people to have the capability of protecting themselves from the consequences of unavoidable extreme events that are due to changing climate and its hazards are dependent upon numerous factors that include access to services, health status, level of education, adequate information, social and available safety nets, and the ability of the government to provide effective support to address challenges (Busby et al., 2014). Hence, societal prosperity is indispensable in determining sustainability since it is indirectly and directly related to the coping strategies engaged by society (Pandey, Kumar, Alatalo, Archie & Gupta, 2017).

Livelihood-enhancing factors are important determinants of the level of climate security. The capacity for a community to cope with climate extremes and hazards is a function of the community's and individual's livelihoods (UNDP, 2013b; Zhou, Kori, Sibanda & Nhundu, 2022). Income, credits and occurrences of social networks have constructive effects on the capacity to reduce vulnerability (Kaczan & Orgill-Meyer, 2019; Zhou et al., 2022). Cevik and Jalles (2022), in their study on 158 countries, found that changing climate vulnerability has no significant statistical effect on the distribution of income in most developed nations, while the coefficient on changing climate vulnerability is about seven times highly significant in the developing economies due to weaker capacity for changing climate mitigation and adaptation where households have reduced capacity and financial ability to adapt and respond to negative impacts of changing climate.

Isuku and Nwafor (2019) affirm that income inequalities cause low-income societies to suffer from the negative consequences of changing climate, which encourages greater inequalities. They further reiterate that income inequalities affect social unity and weaken individual readiness to be involved in collective actions. Empowerment through financial capital such as loans, savings and micro-credits promotes livelihoods for poor families, especially women assisting them to increase their coping abilities against challenges (Kapoor, 2019; Ndhlovu, 2018). This is mainly because family incomes serve as the basis on which the families' wealth for their livelihoods reside (Dang, Gao, Tao, Liu & Xia, 2020). However, city and urban families do rely on social networks in their communities and sometimes workplaces for their support (Yang, Feldman & Li, 2021). Hence, social networks are indispensable in enhancing members of families' ability to survive and recover from shocks (Diem, Pham, Coles, Ritchie & Wang, 2021).

Su, Saikia and Hay (2018) surmise from Frankenberge et al. (2000) and Krantz (2001) that livelihood begins with an examination of the way different people reside in different places. However, human livelihoods are essentially universal that refer to activities pursued by both the rich and poor to make a living (Kidd, Nycander, Tran & Cretney, 2020; Olsson et al., 2014). It is a contestable and progressive paradigm whose definition has been widely adapted and adopted by most authors from Robert Chambers and Gordon Conway (in 1992) who proposed a composite description of livelihoods as the peoples' means of living and capabilities that include income, food and assets (Morse & McNamara, 2013; Natarajan, Newsham, Rigg & Suhardiman, 2022; Saxena, Guneralp, Bailis, Yohe & Oliver, 2016; Scoones, 2015; UNDP, 2017). Karki (2021) and Scoones (2009) describe and analyse livelihoods as the complex web of activities and interactions that emphasises the diversity of ways people make a living. Therefore, livelihoods are made up of the assets, capabilities, entitlements and activities that are necessary for making a living (Amphune, Weldegebriel & Enaro, 2018; Elasha, Elhassan & Ahmed, 2005; Masud, Kari, Yahaya & Al-Amin, 2015; Natarajan et al., 2022). Thus, it underpins well-being and quality of life (Morse & McNamara, 2013; Sina, Chang-Richards, Wilkinson & Potangaroa, 2019). Hence, the interventions for exposure or vulnerability may be determined by the levels of livelihoods (Wang et al., 2016).

The IPCC describes vulnerability as the propensity or susceptibility to being affected adversely, which embraces a predisposition to harm and a lack of capability to adapt (IPCC, 2014b; Sharma

& Ravindranath, 2019). In this context, it is the insecurity or compromised well-being (ecological/ economic/ social/ political) of communities or individuals in the face of environmental change and the case of sudden shocks, seasonal cycles or long-term trends (Drysdale et al., 2020; Farrington, Ramasut & Walker, 2002; Salm, Nisbett, Thornton, Cramer & Gillespie, 2021). The analysis of livelihoods examines the complexity of societies' dependency on the environment by emphasising what causes people to be more or less predisposed to damage from alterations in environmental conditions or climate extremes (Maltais et al., 2003; Tembe, 2022).

Some individuals or groups become more vulnerable to alterations of environmental conditions or climate extremes because they are more predisposed to the impacts of particular risks or do not have the capability to adapt to the risks, which could be due to the type of housing, employment, lack of availability of services or being a migrant (Satterthwaite et al., 2018). The livelihoods of residents in urban communities have a crucial role in their intervention through building resilience and fortifying adaptation strategies to the stresses and negative impacts of changing climate alongside climate extremes.

Su et al. (2018) describe a sustainable livelihood as a livelihood that allows the household or the individual to cope with and also recover from shocks and stress, maintaining the capitals and capabilities that will supply livelihood opportunities for the incoming generation and contributing net benefits to a range of livelihoods at all levels. Therefore, livelihoods will only become sustainable once they can cope with and recover from shocks and stresses and bring about enhancement of their assets and abilities both at present and in the future, and do not undermine the resource base (Elasha et al., 2005; Lax & Krug, 2013). Hence, a sustainable livelihood is essential for human development under a changing climate (UNDP, 2017). In the context of global environmental challenges like changing climate, good and quality urban infrastructure, housing, services, and amenities are indispensable in reducing risks (Satterthwaite et al., 2018).

The concept of the sustainable livelihoods approach was developed to contribute to and enhance the understanding of people's livelihoods (Tembe, 2022; United Nations Office on Drugs and Crime [UNODC], 2011). Hence, the concept was proposed to understand the linkages between livelihoods and socio-economic and environmental changes (Pandey et al., 2017; Saxena et al., 2016). It was founded on the basis that intervention is based upon the appreciation of what fortifies

livelihoods (Fahad, Nguyen-Thi-Lan, Nguyen-Manh, Tran-Duc & To-The, 2022; Morse & McNamara, 2013; Soma, Sukhwani & Shaw, 2022). Therefore, it is a process that is in line with the thinking of sustainable development through the provision of a more practical way of addressing the complexities of multiple survival strategies as it focuses on people, their activities and their resources (Tao & Wall, 2009; Tembe, 2022). The sustainable livelihoods approach is a manner of understanding the process of transformation of livelihoods by policies and activities (Masud et al., 2015; Natarajan et al., 2022). The absence of basic livelihood capital for an individual or a community may worsen their situation when burdened with extreme events, and the individual or the community may become vulnerable to a potential stressor (Pandey et al., 2017). Thus, capability can be destabilised by extreme weather associated with changing climate and may deplete the capital of the households (Kaczan & Orgill-Meyer, 2019).

Most of the work on the concept of livelihoods was primarily and central to rural communities (Pandey et al., 2017; Scoones, 2009). This is mostly because poverty is assumably linked more with rural communities. Therefore, the concept has mostly been engaged in poverty reduction with the notion that poverty must be identified in terms of limitations to capabilities (UNODC, 2011; Yirga, 2021). Urban communities, especially in developing countries at present, have a large chunk of the poor, like their rural counterparts, that are often deficient in some basic needs for their livelihood capital. Previous studies on urban poverty submit that though the stresses and shocks that people are vulnerable to relate to specific circumstances and events, the poor in cities often face a similar set of vulnerabilities which can be classified into urban economy, urban systems of government and urban environment (Farrington et al., 2002; Giri, Bista, Singh & Pandey, 2021; Olajide et al., 2018). Moreover, the rapid and continuing unplanned urbanisation that is common to cities in developing countries mostly in the global south, alongside changing global climate, increases the vulnerability of the urban poor to extreme events (Williams, Costa, Sutherland, Celliers & Scheffran, 2019).

A community or household that is incapable of fulfilling its essential needs for livelihood capital (natural, physical, financial, social and human capitals) may not be regarded as sustainable (Pandey et al., 2017). It does not matter whether it is rural, urban or a city. Thus, there is nothing specifically 'rural' anymore about the concept of the sustainable livelihoods approach as it may be applied to any setting where people rely on a livelihood and could be analysed (Giri, Bista, Singh

& Pandey, 2021; Morse & McNamara, 2013; Olajide et al., 2018). The Sustainable Livelihoods Framework (SLF) has been used in the development discourse as a development objective, analytical framework and process utilised for policy decision-making. It is a process that could track the multi-dimensional phases of poverty both in rural and urban contexts (Fahad et al., 2022; Karki, 2021; Mensah, 2012). Figure 2.3 below shows the SLF components projected for the 21st century including vulnerability contexts such as seasonality, shocks and trends; the main factors influencing livelihoods, and its inner interrelationship as advocated by the Department of International Development (DFID), regarded as one of the main promoters of the framework.

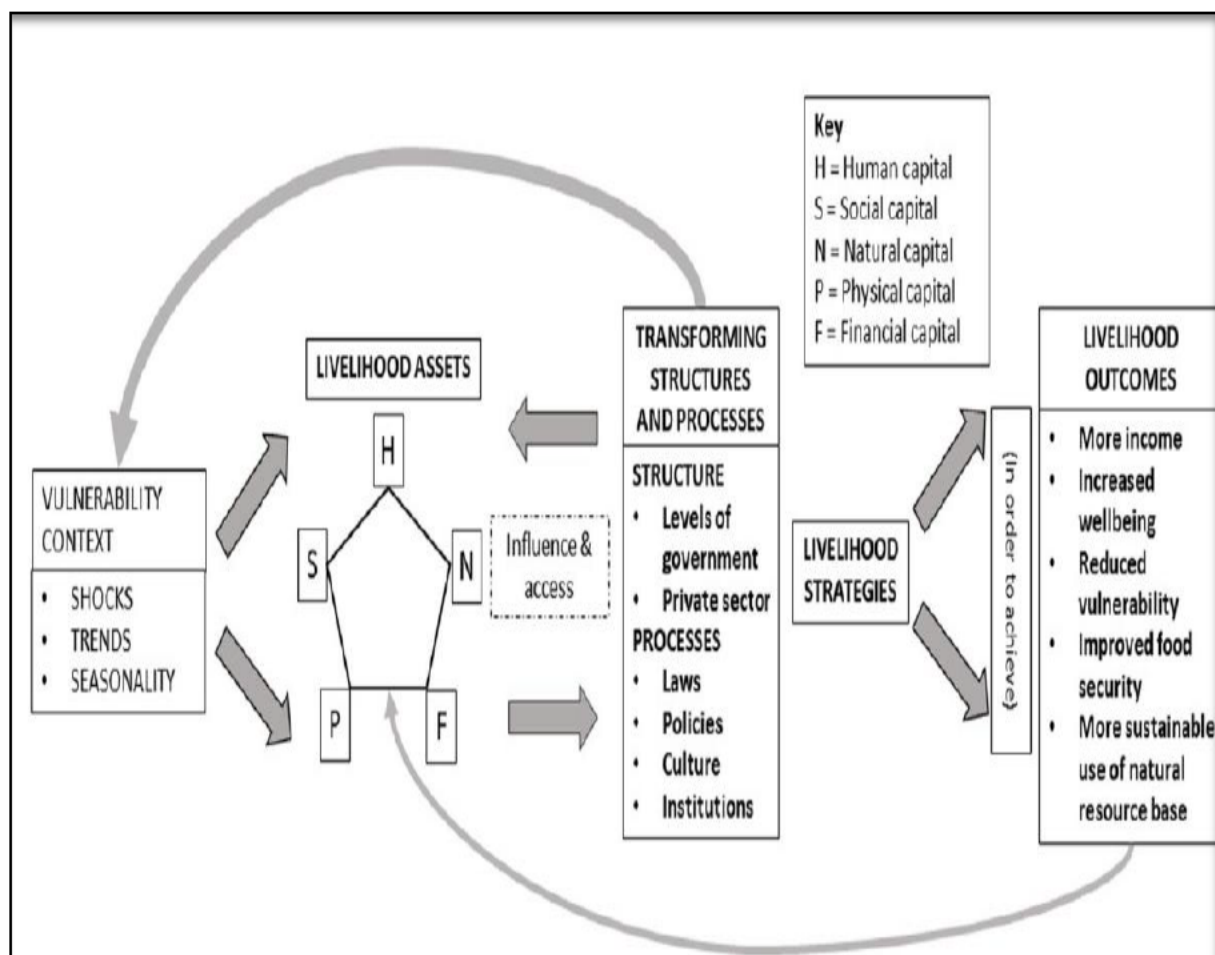


Figure 2.3: 21st century SLF adapted from DFID (2001: 2)

In this context, the sustainable livelihoods approach is used as an analytical framework, and the focus is on the urban environment. The focus on human, social, human, physical and financial capitals in vulnerability contexts is useful to understand livelihood outcomes. As indicated in Figure 2.3, this is a key focus of the SLF, which, extended to urban vulnerable contexts, has underpinned the Sustainable Urban Livelihoods Approach (SULA) and SULF. Therefore, the SULA is a progressive and adaptive structure of the concept of the sustainable livelihoods approach (policy-makers and researchers mostly directed its use to only rural) with a focus on urban areas (Srijuntrapun, Fisher & Rennie, 2017). Hence, this study rests on the principles of the sustainable livelihoods approach in conceptualising the SULF alongside the urban environmental security paradigm in its analysis. The SULF, like its leading concept of the SLF, is a veritable instrument for assessing the implications of climate variability and changing climate on the livelihoods of urban residents and supposedly delineating the necessary interventions against the adverse conditions and shocks generated (Liu et al., 2018; Wilmsen, 2018).

The SULF enhances the understanding of the nature of urban contexts by emphasising that vulnerability is a dynamic concept that focuses its analysis on the notion of capitals (that is, natural, human, social, physical, political and financial) and assets of the urban poor, and their ways of making a living (Elasha et al., 2005; Farrington et al., 2002; Han et al., 2015; Karki, 2021; Meikle, Ramasut & Walker, 2001). The framework places attention on how the individual, household and community obtain the five capitals (natural, human, social, physical/ material and financial), which play a prominent role in sustainable livelihoods that enhances the building of resilience to extreme events due to climate variability and change (Li et al., 2020). This is mainly because the livelihood capitals possessed by a family are indispensable in making decisions for accessible strategies and the associated risks of the decisions (Ding, Jimoh, Hou, Hou, & Zhang, 2018). However, possessing different livelihood capitals makes individuals attain positive livelihood results, thus increasing his/ her choices since it has the ability to be stored, transferred and exchanged in the process of producing income for the household (Ding et al., 2018).

The study also considered that vulnerability to climate variability and impact arises from the demographic and socio-economic characteristics of the city, as noted by Dumenu & Obeng (2016) and Gasper et al. (2011). This is from the perspective that climate variability and change usually compound vulnerability contexts with which urban livelihoods interact, thus leading to huge

potential impacts that are induced by greater levels of risk, intensity, severity and frequency (UNDP, 2013a). Hence, the livelihood perspective embedded in this framework places people at the centre of its analysis rather than being dominated by ecosystems, political contexts, markets, technologies and/ or resource networks (Rehman, Azhoni & Chabbi, 2022; Tanner et al., 2015). The SULF is relevant to understanding the vulnerability associated with changing climate, especially when it offers a framework for examining both the contextual factors influencing them and the vital components of livelihoods (Reed et al., 2013). A well-defined vulnerability context is indispensable in scenario-based planning for adaptation which in turn informs an informed livelihood resilience-building process (Rahman & Hickey, 2020; UNDP, 2013a). Also, the framework identifies with the stance that poor people who are living in marginal conditions may not have jobs, but households may survive through different combinations of sources of livelihood, which may vary in importance from time to time and year to year, constituting a mixed range of commercial and subsistence activities (Tao & Wall, 2009). Hence, the SULF is essential in gearing up action towards climate security in cities. This is on the disposition that building adaptation and resilience to the negative implications of changing climate and its variability in the city by the residents will depend on the livelihood capitals available and activities engaged in.

The study identifies with the practice of the sustainable livelihood approach where human capital is partly related to household size and is dependent on the level of education, gender, age, health, occupation, etc. (Morse & McNamara, 2013). It is a veritable material useful in enhancing individual socio-economic parameters, and its improvement is in the investment of adequate professional and educational training (Golovina, Smirnova & Ruchkin, 2021; Ibrahim, Hassan, Kamaruddin & Anuar, 2018). Therefore, human capital is presumably the bedrock of all other forms of capitals since it enables people to engage in different livelihood strategies to achieve their livelihood objectives (Lax & Krug, 2013). Natural capital is the natural resources where flow and services such as the public goods which include biodiversity, atmosphere, forest, hydrological cycles, agriculture and land that can be derived for individual benefits (Ibrahim et al., 2018; Yang, Jiang & Zeng, 2020). There is, at most times, scarcity of natural capital in a city or an urban centre, which makes it a principally valuable asset, such as in the case of household plots or land where the security of tenure is essential in reducing the vulnerability of the poor in the city (DFID, 2001; Mcevoy, Mitchell, Trundle & Mitchell, 2019).

Srijuntrapun, Fisher and Rennie (2017) reiterate that the most indispensable form of capital in urban areas is financial since most cities have very few areas of cultivation (natural resources) when compared to rural areas. The importance of financial capital cannot be overemphasised since it can be converted into most other capitals and can be used to achieve livelihood outcomes (Wei, Su, Qi & Sun, 2016). Thus, it is crucial to assist people in adapting to diverse livelihood strategies since it is required for the improvement of other capitals (Kassa, 2019; Lax & Krug, 2013). Financial capital refers to financial resources that include cash, liquid assets, bank deposits, remittances, pensions, etc. (Masud et al., 2015). Kassa (2019: 20), citing Scoones (2000), describes social capital as assets that include social relations, networks, associations and cooperatives, with implications on livelihoods. Also, the indispensability of physical capital in determining and supporting urban or city livelihood strategies cannot be overstated. Examples of physical capital to utilise and engage natural capital in cities for positive livelihood outcomes include infrastructure, buildings, pieces of machinery, tools and agricultural inputs (Farrington et al., 2002; Olivier, 2019). Koroma, Rigon, Walker and Sellu (2018) identify physical capital in the informal settlements in Freetown, a developmental economy West African coastal city, and affirm that there is a need for significant investment to acquire physical capital such as a boat or a truck. Hence, the SULF is expected to guide the study through the examination of the implications of changing climate and climate variability on the urban environmental security of Lagos Mega-city with references to the available urban livelihood capitals. Figure 2.4 below depicts the five livelihood capitals highlighting some of their suggested characteristics in line with this study focusing on cities in developing economies.



Figure 2.4: Five livelihood capitals for cities in developing economies

(Adapted from Farrington et al., 2002; Lax & Krug, 2013; Morse & McNamara, 2013)

The concept of sustainable urban livelihoods is expected to have a resultant influence on climate security since it is framed to encourage livelihood strategies and the initiation of the development of sustainable climate policies. It is expected to have a corresponding influence on urban environmental security and, in the end, enhance human security. This is depicted in Figure 2.5 below.

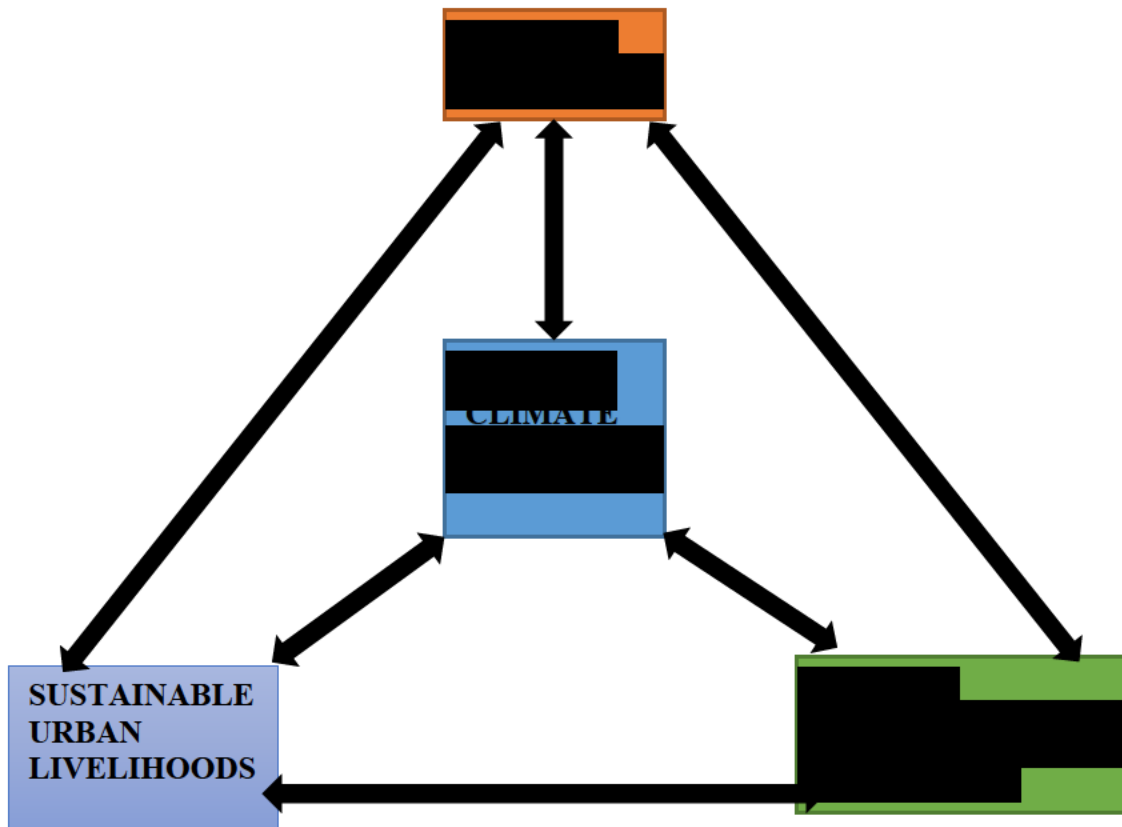


Figure 2.5: Relationships between sustainable urban livelihoods and urban environmental security in a city or urban centre

Through the application of the SULF and urban environmental security, the combined concepts analyse the extent and nature of climate variability in an urban centre or a city and its implication on diverse components of the environments that affect human well-being and livelihoods. Figure 2.6 below depicts an expected relationship between the concepts of SULF and urban environmental security in Lagos Mega-city.

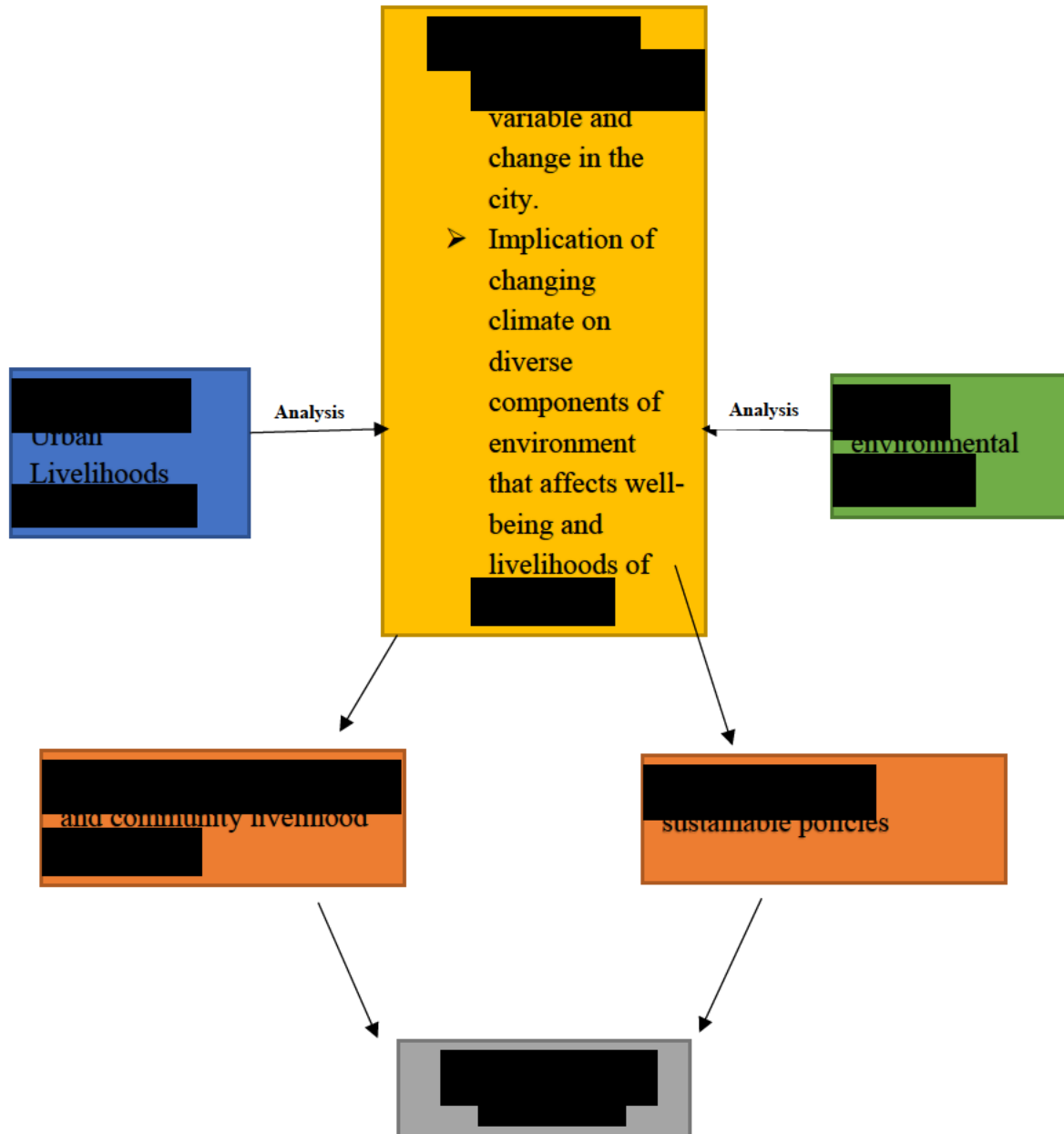


Figure 2.6: SULF and urban environmental security in Lagos Mega-city

The integration of multiple theories provides a useful lens to examine the varied and complex issues in relation to urban environmental security in developing contexts. Specifically, the urban environmental security concept itself is linked to livelihood as well as safety and political security. Political ecology is a closely associated environmental sustainability concept that underscores the

importance of examining historical contexts, environmental justice issues, power dynamics and imbalances (including inequalities and the politics of scale), and governance and institutional considerations. The SULF focuses on livelihood assets (human, social, natural, physical and financial capitals) in the context of vulnerabilities and livelihood outcomes. Thus, the theoretical approaches used provide a comprehensive framework.

2.6 CONCLUSION

Globally, cities have been suggested to contribute inexplicably to changing climate and are also expected to initiate and shape responses towards their sustainable management. Thus, the aspiration of every growing city must be geared towards embracing sustainable norms and enduring practices that will enhance its environmental performance toward socio-economic and environmental sustainability. Sustainable livelihoods and urban environmental security are the underpinning concepts identified as the theoretical and conceptual framework for the study. These are political ecology paradigms that encourage and support sustainable development. Consequently, political ecology theories and concepts have invigorated environmental sustainability processes in many parts of the world through academic and public enlightenment that have propelled and enlivened the practices, instigating diverse frameworks that have supported the initiation of sustainable environmental policies that boost environmental sustainability across the globe. Hence, the two concepts enhance and support holistic and integrative analysis of socio-environmental variables. Thus, they are indispensable in this era of climate variability and change in mediating a process that will encourage urban climate security.

Urban climate security is essential for continuously growing cities to support human development, human security and socio-economic development in the era of climate extremes and extreme events. The livelihoods of individuals and communities, which are the bedrock of adaptation and building resilience, must be sustainably managed and enhanced to support the achievement of climate security. Hence, the use of the sustainable livelihoods approach and urban environmental security provide relevant information for the development of coping strategies by individuals and communities to impacts of changing climate and necessary approaches for institutional development.

CHAPTER THREE

LITERATURE REVIEW

3.1 INTRODUCTION

The exploration of climate change and climate variability phenomena by researchers all over the world is indispensable for human and societal sustainability. Previous studies have implicated the phenomena in instigating food insecurity, biodiversity loss, health insecurity, water insecurity, socio-economic insecurity, conflict, etc. (Adediran, Isah, Ogbonna & Badmus, 2023; Food and Agriculture Organisation of the United Nations [FAO], 2018; Githeko & Woodward, 2003; Intergovernmental Panel on Climate Change [IPCC], 2019; 2022; Kumar, 2021; Rudebusch, 2019). In line with this, a study on China's food security by Liu and Zhou (2021) identified urbanisation and changing climate as part of the key issues that are affecting the country's grain production. Also, Corwin (2020) affirms that there has been quantifiable evidence indicating changing climate patterns impact on the salinisation of agricultural lands apart from its contextual issues with precipitation and seasonality that are prime in food production. The implications of climate variability and change on agriculture and food production as well as livelihoods and well-being more generally cannot be overemphasised.

The shift in the geography of life through changing climate and climate variability are increasingly impacting ecosystem functions with corresponding implications on human well-being and climate itself (Pecl, Araujo, Bell, Blanchard & Bonebrake, 2017). Therefore, changing climate alongside other stressors alter, interfere and modify ecosystems with consequences on biodiversity and the functionality of the entire globe (De la Fuente & Williams, 2023; Malhi et al., 2020; NAS/ TRS, 2019; Nkwunonwo, Whitworth & Baily, 2016). Likewise, the hydrological processes and water security components of the entire globe have their own implications for changing climate. There is an extreme projection of increased precipitation for the coming decades in several areas of the globe with expected implications on the water security and hydrological components (Eekhout, Hunink, Terink, Vente & Diego, 2018). Records show that more than half of the world's population is more than at least one month per year water insecure and also floods, droughts and heat waves threaten the livelihoods and food security of millions of people (Boretti & Rosa, 2019; IPCC, 2022; Mbow et al., 2019). Hence, the impacts of changing climate are parts of the key

stressors that support the continuous growing extreme events in urban societies in different parts of the world, leading to detrimental urban economies that affect human sustainability (Granberg & Glover, 2021; Salimi & Al-ghamdi, 2019). Historically, cities and urban centres in different parts of the world are referred to as one of the main causes of changing climate since they utilise a large proportion of global energy and are responsible for the world's energy-related greenhouse gas emissions (IPCC Press, 2022; The Guardian, 2015). Cities are also found to have the capacity to offer the solution that will ameliorate the impacts of changing climate through their complex roles as hubs of governance, economic growth, creativity, and innovation (Alvarez-Risco, Tapia-Meza & Del-Aguila-Arcentales, 2023; Revi et al., 2014; The Guardian, 2015; United Nations Human Settlements Programme [UN-Habitat], 2019).

Policy-makers and scientists describe the 21st millennium as the urban millennium because of the continuous urbanisation that is presently witnessed in different parts of the world, which results in more than half of the world's population being residents in urban areas (Anselm, 2019; Breckenkamp, Patterson, Scharlach, Hellmeier & Verma, 2017; United Nations, 2008; 2015; Yakubu, Ojo & Yakubu, 2020). However, the rapid urbanisation and the continuous growth of cities, especially in most developing countries, have resulted in the emergence of vulnerable urban societies, mostly through inadequate land management and informal settlements (Granberg & Glover, 2021; IPCC, 2012; Satterthwaite, Archer, Colenbrander, Dodman & Hardoy, 2018). Additionally, the emerging risks of the globally changing climate are concentrated in cities (Maplecroft, 2018a; Reckien et al., 2017; Revi et al., 2014). Consequently, there is a need for the security of urban residents from the implications of changing climate and climate extremes.

This chapter reviews the literature on climate variability and change, alongside urbanisation, urban agglomeration, urban growth, and cities through the lens of environmental security concepts. Diverse topics and issues on the concepts relevant to the research are reviewed in a single body of writing that involves diverse themes and sub-themes that align with the study's orientation, as Chowdhury (2019) advocates. Moreover, the chapter analyses and describes the concepts holistically using global instances and tapering them to the region, then narrowing it to the local, with an emphasis on Lagos Mega-city, which is the case study.

3.2 URBANISATION TRENDS AND ISSUES

The concept of urbanisation is framed from the term urban. Urban relates to a town or city. Its definition worldwide has no specific structure, but it is always based on the threshold of population size or demographic status in conjunction with or without other stipulated criteria of a country (Ritchie & Roser, 2019; Wineman, Didier & Anderson, 2020). Also, the criteria and population density or size are not expected to be globally the same or uniform but are always localised (Breckenkamp et al., 2017; Ofem, 2017; United Nations Department of Economic and Social Affairs [UN DESA], 2008). The features and expectations of most urban areas are determined by their specific state and country with periodic reclassifications (Mcgranahan & Satterthwaite, 2014; United Nations International Children's Emergency Funds [UNICEF], 2012); Wineman et al., 2020).

Urbanisation is the continuous shift of residents from rural settings to urban settings. Thus, it is a process of a shift in the population from small rural communities towards populated or thick urban communities characterised by industrial activities and social services (United Nations, 2015; Yakubu et al., 2020). Hence, it increases the percentage of the population residing in urban centres (Adekola, 2017; Jiboye, 2011). Subsequently, the practice of urbanisation is expected to lead to the growth of cities.

Urbanisation may create a change in the social, cultural and economic conditions of a society (Hussain & Imitiyaz, 2019; Punyamurthy & Bheenaveni, 2023). Most growing cities are drivers of social disparities and territorial fragmentation (Bolay, 2020). However, the challenges of urbanisation are visible in some of the fast-growing developing countries' cities, especially when most of their developed infrastructure was built many years ago with capacities that are now far below their present needs, which include water treatment amenities, sewage treatments plants and waste management facilities (Obia, 2016). The task is not how to control urban growth but the sustainable management of urban transition (Mcgranahan & Satterthwaite, 2014).

The process of urbanisation is not a recent concept but a long-time historical paradigm that scholars began to give special attention to around the mid of the 20th century (Awumbila, 2017; Breckenkamp et al., 2017; Opoko & Oluwatayo, 2014; Schneiderbauer et al., 2021). However, urbanisation, urban growth and urban expansion are not the same, although scholars and policy-

makers often use the three words interchangeably. Urban growth and urban expansion could be regarded as part ingredients of urbanisation. Urban growth is the absolute or relative increase in the number of people who live in cities and towns (Avis, 2019). Increases are dependent on the natural increase in a city's population, gains from the rural-urban shift and/ or the reclassification of rural settings into towns and cities (UNICEF, 2012; Wineman et al., 2020). Urban expansion is the increase and extension of developed land areas by cities and towns (Angel, Parent, Civco & Blei, 2012; Fox & Bloch, 2018; Wihbey, 2017).

The population of the world was about 7.6 billion as of mid-2017 and is expected to increase by more than one billion from 2017 to 2030, and estimated to get to about 8.6 billion in the year 2030, 9.8 billion in 2050 and 11.2 billion people by 2100 (United Nations, 2017). However, there has been a rapid global urbanisation trend which has led to the expansion of urban centres since the last century. The urban population globally increased from 200 million (which was approximately 15% of the world's population) in 1900 to 751 million people in 1950, continued to 2.9 billion (which was about 50% of the world population) in 2000, and grew to above 4 billion in 2018, which is more than half of the population of the world (Ritchie & Roser, 2019; United Nations, 2015; 2018b). The projection of the global urban population in 2014 was 54% and 56.2% for 2020, 60.4% for 2030, 64.5% for 2040 and 68.5% for 2050 (United Nations, 2015; 2018b). The population records, estimations and projections for this century have further shown that the urban population worldwide will continue to increase. Randolph and Storper (2023) assert that the pace and scale of urban population growth in the global south are particularly rapid.

Figure 3.1 below from the '2014 UN World Urbanisation Prospects' document of the United Nations depicts the urban population alongside the rural population in millions from 1950 to 2050. It shows graphically global urbanisation and rural trends. It further shows a continuous increment globally for the urban population while the rural counterpart was approximately steady from around the year 2007. This means the global urban settings started to grow in population more than the rural areas since the year 2007 and will grow continually to the extent that by 2050 there will be 34% rural and 66% urban populations, which will be the opposite of the population distribution of rural-urban in 1950 (Hussain & Imityyaz, 2019; United Nations, 2015).

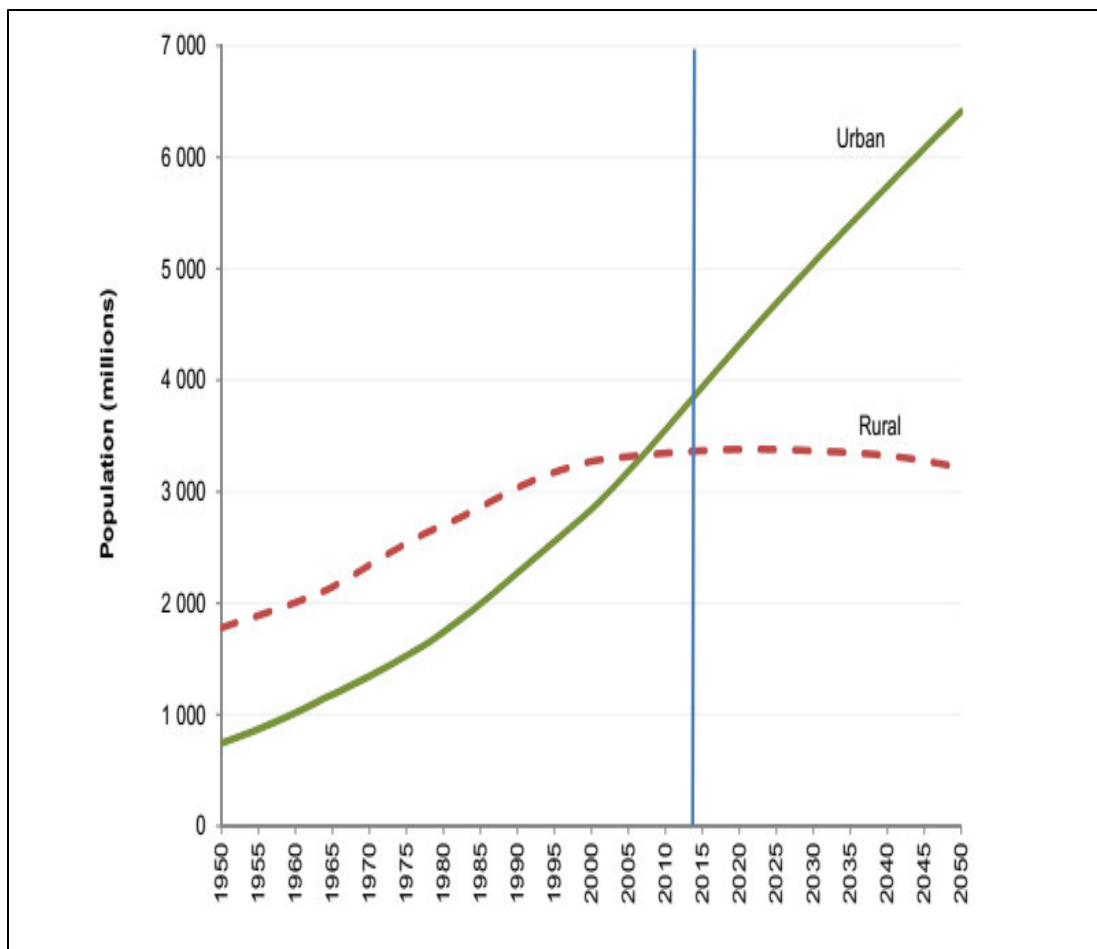


Figure 3.1: The world’s rural and urban population (United Nations, 2015: 7)

The continuous and rapid urbanisation in the world has led to a rise in the number of nations that are urbanised in recent times, with the expectation to continue increasing in the upcoming decades (United Nations, 2015; Li, Zhao, Wang, Zhao, Liu, & Li, 2022). Asia is regarded as a continent with a lesser level of urbanisation but China, its most populous country, alone makes up about 20% of the global urban population, with Europe having 14% and Latin America and the Caribbean having about 13% (Bolay, 2020). Hua, Mingxing and Chen (2022) reported that the urbanisation levels of China increased from 17.92% in 1978 to a staggering 63.98% by 2022, which represents an annual urbanisation rate increase of 1.09%.

Records have shown that about 54% of the globe now resides in urban areas, and the urban population of the Americas and Europe has reached about 80%, while that of Africa and Asia is still less than 50% (Bolay, 2020). The levels of urbanisation are projected to increase across all

regions around the globe in the upcoming decades, but Asia and Africa are expected to urbanise faster than the rest of the world (Kundu & Pandey, 2020). Around the 1950s, 59% of the high-income countries' populations lived in urban areas, and it has increased to about 81% by 2018 and is projected to increase to 88% in 2050, while the lower middle-income and lower-income countries' urbanisation has been slower with the current population in urban areas being 41% and 32% but with expected projections of 59% and 50% in 2050, respectively (United Nations, 2019). Figure 3.2 below depicts the levels of urbanisation in different parts of the world in the years 1950, 2014 and the projection for 2050.

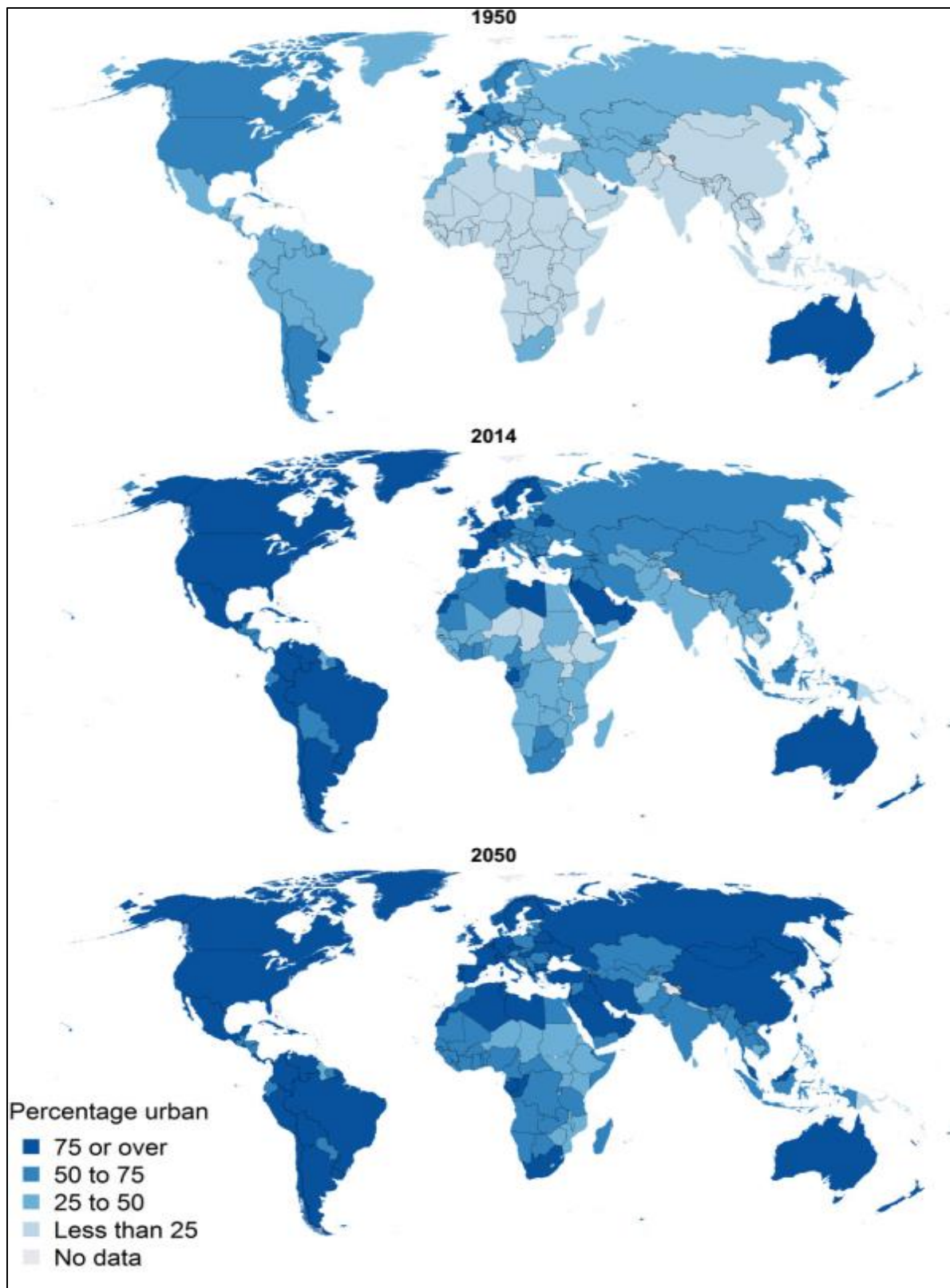


Figure 3.2: Percentage of population residing in urban areas in 2050 (Bolay, 2020: 10)

In less developed regions such as sub-Saharan Africa, Eastern Asia and Western Asia, the speed of urbanisation has been rapid when compared to developing countries since 1950 (United Nations, 2018a). Sun, Chen, Li and Huang (2020), in their analysis of 841 cities that were large in different parts of the world in recent past decades with built-up-areas of over 100 km² from 2001 to 2018, showed that global urbanisation in countries with diverse income groupings in recent past decades showed a dramatic unevenness for different economic classifications. The research further reiterated that large cities in lower-middle-income and low-income countries had the highest urban population growth and built-up areas expansion. For example, the urban population in Eastern Asia, which is a developing region, increased from 18% to 60% between 1950 and 2015 (more than three times), whereas a comparable change in the developed region took about 80 years between 1875 and 1955 (United Nations, 2018a). Figure 3.3 below depicts the trends in urbanisation in different regions of the world from 1880 to 2015, with the black line signifying urbanisation in the developed regions, which is the basis for comparison, while the less developed nations begin with 1950 and other regions have different colours.

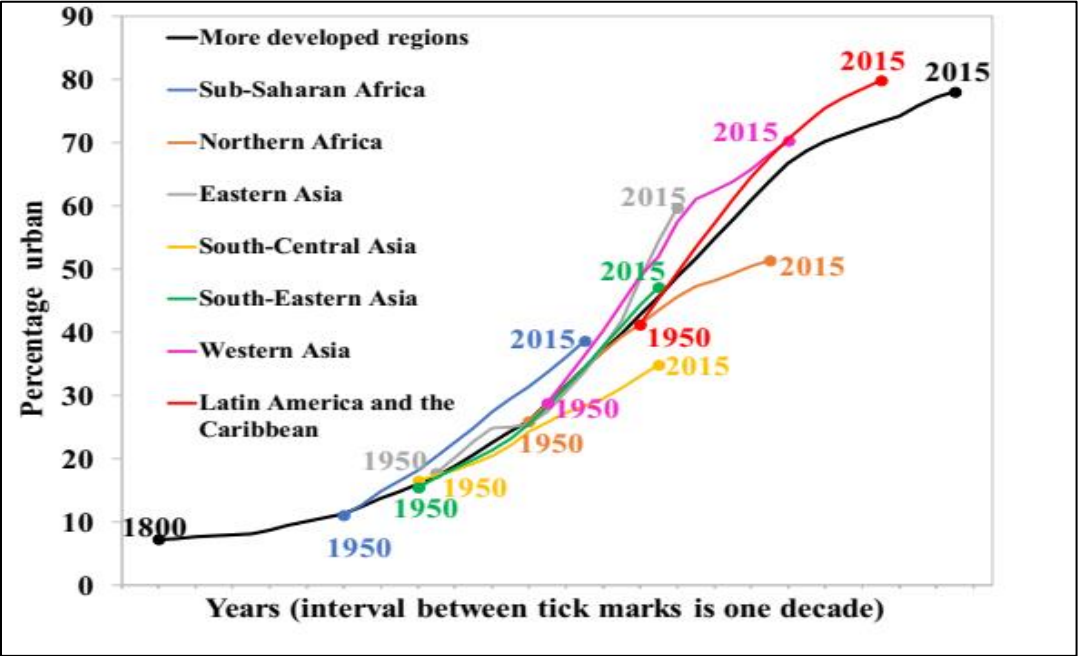


Figure 3.3: Trends and levels of urbanisation in developing regions in comparison to other regions (United Nations, 2018a: 2)

Urbanisation and urban growth may occur concurrently, but there is a possibility of a rise in urban growth that is owing to mostly natural or indigenous population growth rather than urbanisation (Bai et al., 2017; Farrell, 2017). Hence, to sustain urbanisation's influence on city dwellers, there is a need for strong economic growth that supports enterprises (Onyango, 2018). This is because commerce, economic development and enterprises make an urban centre to be attractive to rural dwellers. An extensive study on 90 developing countries in different parts of the world affirms that urbanisation is associated with poverty reduction when there is only robust economic growth in the city (Turok & Mcgranahan, 2020).

Economic growth has often been regarded as the main driver of urbanisation, though there has not been a relationship between the size of the city and its productivity (McGranahan et al., 2005; Turok & Mcgranahan, 2020). However, Gollin, Jedwab and Vollrath (2016) surmise that although sometimes urbanisation is used synonymously with industrialisation, there are rural-urban migrations that may not be connected to industrialisation but are empowered by other societal forces or factors. The authors further reiterate that nations that depend mostly on resource exports seem to have their urbanisation connected to their consumption cities where their economy rest on non-tradable services as compared to cities in industrialised nations that are not significantly exporting resources but having employment in the industrial sectors which are the basis for their urbanisation. Though, there has been a general assumption that the rural poor migrate to cities for mostly employment and higher wages (Abeje, 2021). However, other societal factors that may influence urbanisation include urban socio-political status, physical infrastructure, improved public services, socio-cultural issues, governmental policies, socio-economic advantages, etc. (Bhatta, 2010; Biswas, Kabir & Khan, 2019; Hove, Ngwerume & Muchemwa, 2013; Punyamurthy & Bheenaveni, 2023).

Biswas et al. (2019), in a study on urbanisation in Bangladesh, found that there was a difference between male and female migration to cities, with 64.8% of the migrated women moving to the city for family purposes while 85.3% of men migrating to the city for employment whereas, in the recent years, the female migrants were found to be involved in garment making as a source of income. Abeje (2021) found in the study on rural-urban migration in Ethiopia that single and mostly young men from the Amhara region migrate to cities to cope with poverty because of their landlessness which makes them lack means of subsistence, while some want to be free from family

control and responsibility whereas others (male and female) move to cities to avoid socio-cultural practices which include early marriage. Yeboah (2021) reports that the youth aspirations in the Cocoa growing areas of Ghana are to migrate from rural areas to cities to obtain a university education that will assist them in getting better employment opportunities apart from some with the expectation of engaging in farming to gather enough funds to acquire a vocation.

Apart from indigenous urban population growth, rapid urbanisation has been encouraged through the rural-urban shift and is expected to continue over decades in more impoverished or developing countries because of the continual deterioration of rural livelihoods, which makes many rural dwellers develop an interest in residing in urban areas for better living (Mberu, Béguy & Ezeh, 2017; McGranahan et al., 2005; Simon & Leck, 2010; Turok & Mcgranahan, 2020). Gollin et al. (2016) surmise that rates of urbanisation may not be dependent on industrialisation because many developing countries such as Kuwait, Saudi Arabia, Angola, Gabon, Libya and Nigeria have high levels of urbanisation with slight industrialisation.

The urban transition, which is the transformation of society from predominantly rural settings to large urban areas, has become a common event in some parts of the world, and it always comes without a uniform process but has different patterns, determinants and outcomes (Farrell, 2017; 2018). The world's population has generally been increasing due to the increase in birth rates and declines in death rates due to the increase in food supply, food distribution, improved nutrition, sanitation and advanced health practices (Sheykhi, 2020). Social and economic changes have contributed immensely to the decrease in mortality rates in different parts of the world (Shennan & Sear, 2020). Thus, the urban population growth has been accelerated by changes in mortality, fertility and rainfall (weather) patterns, conflict and the increasing urban in-migration over its out-migration because of cities' better ways of connecting to education, higher income, surplus skilled and unskilled labour (which enhances personal economy), and access to amenities and recreation (Farrell, 2017; Fox & Bloch, 2018).

Nigeria as a country has been having dramatic urbanisation, as experienced in most developing countries since around 50 years ago, and is similar to the urbanisation process witnessed in developed countries (Bartholomae & Schoenberg, 2019; Farrell, 2017; Gollin et al., 2016). The threshold population size for what is deemed to be urban in Nigeria is 20 000, which has not been

reclassified for a while, restricting the number of official urban areas to 774 even with the country's landmass of 923 768 km² (Avis, 2019; Ofem, 2017). However, Nigeria's population statistics have shown increasing urbanisation as it is in some parts of the developing world in recent times (Adekola, 2017; Mberu et al., 2017; United Nations, 2019). The natural population increment plays a significant and possibly leading role in driving urban population growth in Nigeria through declining mortality alongside the persistently high fertility rate that is experienced in the country (Avis, 2019; Bloch, Sean, Monroy & Ojo, 2015; Farrell, 2018; Fox, Bloch & Monroy, 2017; Nigeria Bureau of Statistics [NBS], 2018). The annual national population growth rate for Nigeria is 3.2% (NBS, 2018). Table 3.1 below depicts the data of the United Nations 'World Urbanisation Prospects: The 2018 Revision', showing the urban percentages and urban population and projections for Nigeria from 1950 to 2050. Figure 3.4 shows the increasing percentages of the urban population in Nigeria.

Table 3.1: Urban population and urban percentages and its projection for Nigeria from 1950 to 2050

Year	1950	1960	1970	1980	1990	2000
% Population	9.4	15.4	17.8	22	29.7	34.8
Urban Population in thousands	3,540	6,956	9,942	16,139	28,276	42,627
Year	2010	2020	2030	2040	2045	2050
% Population	43.5	43.5	59.2	64.9	67.4	69.9
Urban Population in thousands	68,950	107,113	156,300	216,084	250,285	287,130

Data extracted from United Nations 'World urbanisation prospects of 2018' file 19 (United Nations, 2019)

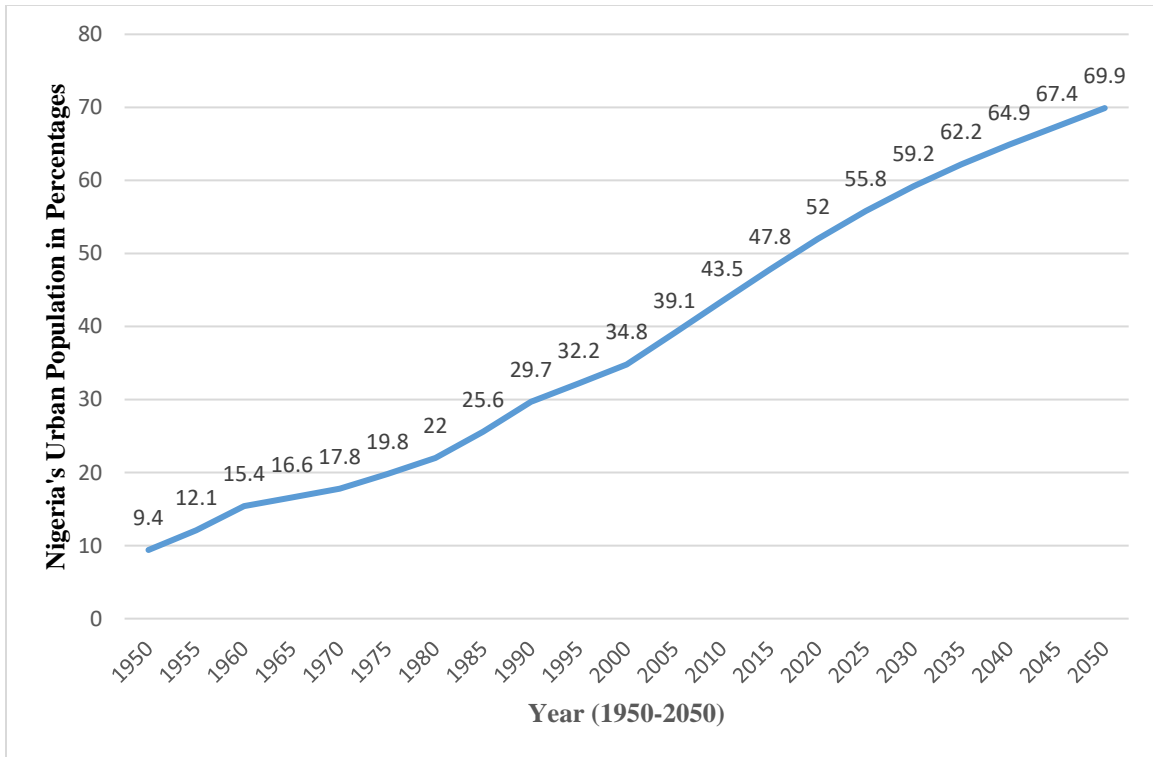


Figure 3.4: Increasing percentages of urban population in Nigeria (data extracted from the ‘World Urbanisation Prospect of 2018’, United Nations, 2019)

In the year 2018, the total population of Nigeria, according to the United Nations (2019) data, was 195 875 000, with the urban population at 98 611 000 and its rural counterpart at 97 264 000, making the urban population around 50%. The urbanisation trend in Nigeria is mostly internal migration from rural to urban centres (Adekola, 2017). This rural-urban shift is driven by the concentration of development programmes and social activities, which include increasing employment opportunities in the urban areas and limitations of economic prospects in the rural settings shifting from a slim economic standpoint to wider sustainable well-being that focuses on strategies that encourage regional development and actions that might alter rural-urban relations (Awumbila, 2017; Babanyara, Usman & Saleh, 2010; Knickel et al., 2021; Nkalu, Edeme & Nchege, 2019). Figure 3.5 below from the Country Profile (Nigeria) of the World Urbanisation Prospects of 2018 depicts the increasing urban population in Nigeria from 1950 to 2050 and the continuing decrease in its rural population from 1950 to 2050 (United Nations, 2018c). It also showed that by 2018, the population in urban areas was equal to the population in rural areas.

These urban-rural area statistics invariably suggest that there is a continuous rural-urban migration when considered alongside the increasing total population of the country.

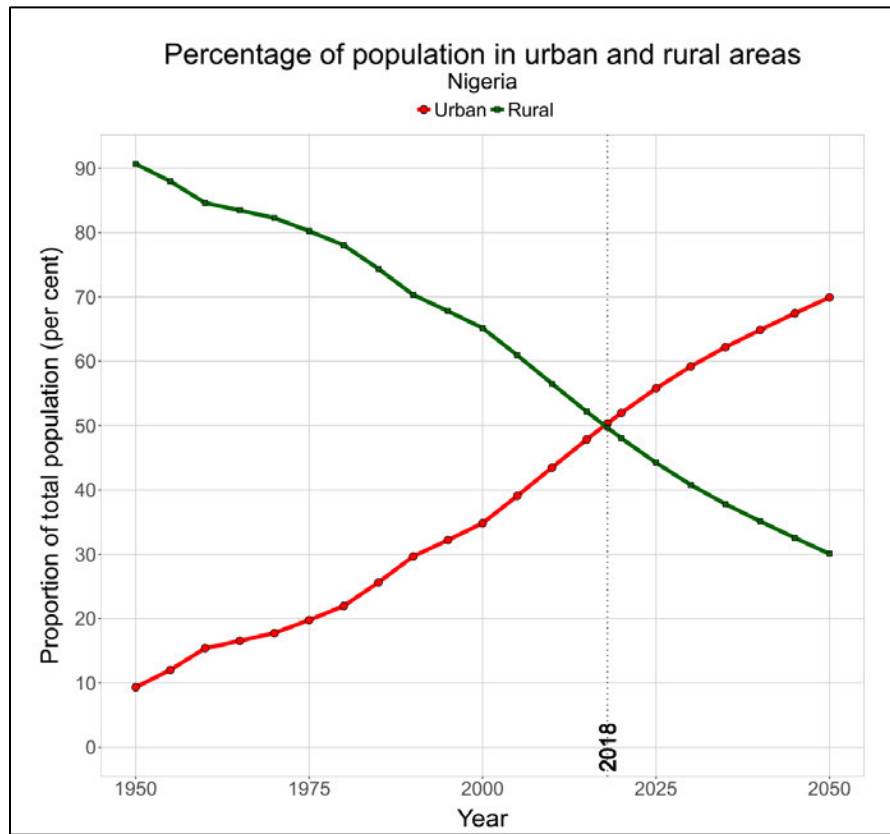


Figure 3.5: The percentage population in urban and rural areas in Nigeria from 1950-2050 (United Nations, 2018c)

Farrel et al. (2018), in a study on Nigeria that was built on previous work undertaken by Fox et al. (2017), disaggregated urbanisation into the individual components of urban growth (which are urban natural increment, rural-urban migration and reclassification of rural areas to urban or administrative centres). The study examined Nigeria's urban transition for a 50-year period between 1960 and 2010 and agreed on the limitations of relying on only national growth since separate data on the growth rate of rural and urban populations were not readily available. The study argument was based on their investigation that the urban natural increment remains the driver that sustains the Nigerian urban transition than rural-urban migration in the post-colonial period (after 1960) since it contributed the highest portion (53% and 48%, respectively) to urban growth

both in the initial stage of the urban transition period (between 1960-1980) and the urban transition early accelerated period (between 1980-2010) (Farrell, 2018). Table 3.2 below depicts the percentage contributions to urban growth, which include urban natural increment and rural area classification.

Table 3.2: Percentage contribution to urban growth in the initial stage of urban transition and urban transition early accelerated stage in Nigeria

	Urban transition initial stage % (1960-1980)	Urban transition early accelerated stage % (1980-2010)
Urban natural increment	53	48
Rural-urban migration	25	37
Rural areas reclassification urban	22	15
Total	100	100

Data adapted from the rapid urban triad (Farrell, 2018: 293)

The knowledge of the urbanisation trends and issues is significant for the adequate and sustainable planning of cities in urban societies, urban governance and the government in their process of building a sustainable city. Understanding urbanisation patterns is also important for the achievement of urban environmental security, which is essential in this changing climate and climate variability era. This is because the knowledge of urbanisation trends by policy-makers and urban researchers enliven the future demographic and features expected of cities alongside the imminent change in socio-cultural, economic and environmental parameters that will be associated with projected urban growth. It will also avail the policy-makers, urban societies and government officials the opportunity to develop infrastructure, technology and capacity, which include nature and people-oriented sustainable programmes ahead of time that will support urban environmental security and, in the long-term, encourage its urban climate security.

3.3 URBAN AGGLOMERATION OF CITIES

An urban agglomeration is an evolving concept that has emerged to express the levels of geographical expansion, extension, population growth and influence of a growing city upon its neighbouring urban centres and cities. It is a developing and progressive concept that has been existing for a long time. Scholars and policy-makers over the past 100 years have used several terms for urban agglomerations at different phases of socio-economic and human development. These include urban clusters, clustered cities, integrated urban regions, concentrated urban areas, megalopoli, city communities, extended metropolitan areas and township agglomeration (Fang & Yu, 2017).

Generally, an urban agglomeration is a technical term highlighting the extent and morphology to which large cities having urban economic zones integrate with a group of urban areas or cities that share a common fate and interest (Loibl, Etminan, Gebetsroither-Geringer, Neumann & Santiago, 2018). Fang and Yu (2017) surmise that urban agglomeration is a developed spatial form of integrated cities or urban centres that focus more on cooperation rather than competition. They further reiterated that it encourages the relationships among cities for cooperation and competition, which makes it indispensable for global socio-economic development. Thus, it creates numerous economic activities, such as attractive consumer amenities apart from the pool of the labour market, which engenders several advantages (Farinmade, Soyinka, Wai & Siu, 2018; Strange, 2008).

Cities experiencing urban agglomeration are in different parts of the world though they are mostly in the global south rather than the global north. Such include Beijing, Nanjing and Wuhan in China, Seoul in South Korea, Karachi in Pakistan, Johannesburg in South Africa, Paris in France, Santiago in Chile, Houston in the USA, and Lagos, the case study. Table 3.3 below depicts the populations of these urban agglomerations in 2000, 2018 and 2030.

Table 3.3: Urban agglomeration cities in different parts of the world

Country	City	City population in millions		
		Year 2000	Year 2018	Year 2030
USA	Houston	3.847	6.150	7.254
Chile	Santiago	5.658	6.680	7.343
France	Paris	9.737	10.901	11.710
South Africa	Johannesburg	3.040	5.480	6.978
Pakistan	Karachi	9.825	15.400	20.432
South Korea	Seoul	9.879	9.963	10.163
China	Wuhan	6.638	8.176	9.611
China	Nanjing, Jiangsu	4.279	8.245	11.011
China	Beijing	10.285	19.618	24.282

Data from the World Cities in 2018 (United Nations, 2018b: 11-29)

The benefits of urban agglomeration from a policy perspective depend on specific investments made by national, state and local governments to improve how cities function and the mobility of enterprises and workers to productive locations that will facilitate matching, learning and sharing (Turok & Mcgranahan, 2020). Inadequate preparation for rapid urban growth and expansion, particularly when there are continuous agglomeration and increasing natural populations, will alter urban ecology, biodiversity and ecosystems (Grimm et al., 2008; Ruas, Costa & Bered, 2022; Wu, 2014). Thus, urban expansion alters ecosystems services and community provisions such as the land for agriculture and natural vegetation that is lost to continuing growing impervious surfaces in urban centres and cities, hindering food provision, carbon storage and freshwater provision (Forman & Wu, 2016; Zhang, Huang, He & Wu, 2017).

Ecosystems provisions and services are indispensable to the sustenance of urban livelihoods and well-being (Ayeni & Aborishade, 2022; Egoh et al., 2012; Landreth & Saito, 2014). Therefore, sometimes, rapid urban growth and expansion could be seen as socio-economic threats in some developing countries (Cobbinah et al., 2015). Also, there is an interaction between urban agglomeration, heat stress and changing climate (Chen, Zhou, Hu & Zhou, 2020; Oleson et al., 2015). The heat-related stress that is generated in cities is associated with the convergence of the increase in global average temperature and the urban heat island (UHI) (Goodess et al., 2021; Reckien et al., 2017). Thus, the UHI is experienced through urbanisation resulting from urban agglomeration that is linked to variations in energy fluxes in cities resulting in changes in the micro-climate as well as degradation of the thermal environment through excess building stock

and land take (Akbari et al., 2016). UHI is a concept that describes the conditions that are common to a city centre, having higher ambient air and near-surface air temperatures when compared to its adjoining communities (Huang, Zhou & Cadenasso, 2011; Yu et al., 2020). It accounts for the accumulation of heat in cities that is due to the diverse thermal behaviour of city materials concerning the natural ones, changes in vegetation coverage, the specific urban geometry and the presence of anthropogenic heat emissions (Acero & González-Asensio, 2018).

Apart from the temperature rise that has been associated with UHI, it may lead to an increase in the temperature of the water body, a decrease in the diversity of water, and also has an effect on rainfall patterns in cities (Ping, Alias, Aghamohammadi & Aghazadeh, 2017). Thus, it is an anthropogenic urban climate phenomenon that is common to growing cities. The intensity of the UHI in a city depends intensely on the characteristics of the growing urban community, the local meteorological features, the synoptic conditions, the kind of urban materials, and the existence or lack of green areas (Akbari et al., 2016). Previous studies have shown that UHI exists on every continent, excluding Antarctica, which makes it a global phenomenon affecting numerous cities in different parts of the world (Ren, Laforteza, Giannico, Sanesi, Zhang & Xu, 2023; Wong, Paddon & Jimenez, 2013).

Some of the continuously growing big cities in different parts of the world where increasing UHI has been documented in the literature include Beijing in China, London in the United Kingdom, Mexico City in Mexico, Kuala Lumpur in Malaysia, New York in the USA and Mumbai in India (Ping et al., 2017; Wong et al., 2013). The United Nations (2018a) shows that some of the continuously growing cities in Nigeria, which include Lagos Mega-city, are also experiencing urban agglomeration which has amplified their populations. Other cities identified include Abuja in the Federal Capital Territory, Aba and Onitsha in the Eastern Region, Benin City in the Mid-Western part, Kano in the Northeast, and Port Harcourt in the South. The record also depicted two of the cities, Kano and Abuja, are already having a population that is above 2.5 million and are expected to have a population that will be above 5 million in 2030. Table 3.4 below depicts the population of these cities in 2000, 2018 and 2030.

Table 3.4: Population of some Nigeria cities experiencing urban agglomeration in 2000, 2018 and 2030

City	City Population in Millions		
	Year 2000	Year 2018	Year 2030
Kano	2.602	3.820	5.551
Port Harcourt	1.091	2.731	4.595
Abuja	0.833	2.919	5.119
Aba	0.630	1,023	1.1527
Benin City	0.975	1.628	2.451
Onitsha	0.533	1285	2.138

Data from the World Cities in 2018 (United Nations, 2018b: 12)

Urban agglomeration in Lagos Mega-city has also supported a consistent increase in population growth and expansion with implications on its land cover, landform and land use (Farinmade et al., 2018; Guo, Di, Zhang, Lin, Chen & Molla, 2022; Oluwafeyikemi & Julie, 2015). The implications on its land cover through land use changes have led to an increase in the land surface temperature (LST) which indicates the UHI of the city (Ayanlade & Jegede, 2015; Dissanayake, Morimoto, Murayama & Ranagalage, 2019; He, Zhuang & Liu, 2007). This finding is similar to a study conducted by Igun and Williams (2018) on the land cover of the city using the emissivity-corrected land surface temperature method, where the LST map of 9 local governments in the city in 2002 was compared with that of 2013. The study identifies that there has been an overall increase in LST in the study areas with an upsurge in their surface temperatures (Igun & Williams, 2018).

Babalola & Akinsanola (2016) analysed the spatial distribution of changes in Land Use Land Cover (LULC) of 5 local governments in the city for 1984, 2001 and 2013 using Landsat images through a quantitative approach to explore the relationship among land cover area, land surface temperature and Normalised Difference Vegetation Index (NDVI). It was found that vegetation cover has decreased from 10.127% to 70.043% over the 30 years period, which has led to an increment in the UHI intensity (Babalola & Akinsanola, 2016). In a recent urban landscape metric analysis conducted on four cities in Africa (Lagos in Nigeria, Addis Ababa in Ethiopia, Lusaka in Zambia and Nairobi in Kenya), the study shows a relationship between the mean LST, impervious surfaces, and green spaces and revealed Lagos Mega-city with the highest percentage of impervious surface was warmer, and Nairobi with the minimum mean LST of impervious surfaces was the coolest (Simwanda, Manjula, Estoque & Murayama, 2019).

UHI, alongside changing climate, has been documented in a previous study in Kuala Lumpur to have a negative substantial negative impact on workers' health, leading to a decrease in labour productivity (Ping et al., 2017). Therefore, urban agglomeration instigating UHI in this era of climate variability and change may lead to unfavourable warming of the environment, which could have serious implications on the health and quality of life of dwellers as well as the socio-economic system of the city (Akbari et al., 2016; Chapman, Watson, Salazar, Thatcher & Mcalpine, 2017; Chen et al., 2020; Heaviside, Macintyre & Vardoulakis, 2017; Ping et al., 2017; Sachindra, Ng, Muthukumaran & Perera, 2016; Wong et al., 2013).

The urban environmental security of the city depends on the sustainable management of the components of urban agglomeration, which include the levels of geographical expansion and extension that are witnessed in a city in this changing climate era and the implications on the city and its environment. This is mainly with the understanding that continuous urban expansion and extension will alter city ecosystems with implications on its provision and services that are the bedrock for human livelihoods. Hence, there is a need to understand the nature and types of agglomeration in a city to embrace sustainable approaches for the sustenance of ecosystems that is essential for urban livelihoods.

3.4 CLIMATE CHANGE AND CLIMATE VARIABILITY

Climate change and climate variability are the functions of the climatic conditions of a place or a point (Australian Academy of Science [AAS], 2020; National Aeronautics and Space Administration [NASA], 2022). Matthews (2018) affirms that they are part of the critical global contemporary issues that are coined out of the word 'climate' because of their interconnectedness with the atmosphere and the human environment. Hansen (2018) and Riedy (2016) describe climate as the average state of the weather in a particular place over some period, including the pieces of evidence of its variability. Climate is the mean weather patterns of a region that are usually tracked for a minimum of 30 years (National Geographic Society [NGS], 2022a). On the other hand, the state of the weather of a place is the atmosphere of a particular location at a specific time that may consist of its meteorological elements which include temperature, rainfall, cloudiness, humidity, winds, etc. (Adedeji, Reuben, & Olatoye, 2014; Cubasch et al., 2013; NGS,

2022b). Thus, the weather could be described as the conditions of the atmosphere parameters from about an hour to weeks (AAS, 2020).

Article 1 of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992 describes climate change as the change in climate ascribed directly or indirectly to the activities of humans that alter the global atmospheric composition, which is in addition to the natural variability of climate witnessed over comparable periods (Matthews, 2018). Such human activities influence the changing of the atmospheric greenhouse gases, which include Carbon Dioxide (CO₂), altering aerosol concentrations, and altering the Earth's surface reflectivity through changing global land cover (AAS, 2020).

Climate change is the long-term change in the mean weather patterns that expresses the global, regional, and local climates (NASA, 2020a). Also, it could be described as a change in the computational properties of the climate system that continues for some decades, usually above 30 years (AAS, 2020). Therefore, it embraces the change in both the average climatological values and the variations or deviations within these values (Umar, Ramli, Aris, Nor & Sulaiman, 2019). Equally, it is the principal change in the modern climate that is amplified by human activities (Rahman, 2013). However, anthropogenic-induced climate change overlaps with natural climate change at regional scales (National Research Council, 2010; Malla, Mushtaq, Bandh, Qayoom, Hoang & Shaid-e-Murtaza, 2022).

Changing climate and its variability is not a new phenomenon. It is a relatively slow process in its natural phase that takes about 100 000 years owing to changes in certain external and internal forces in and on the earth, which include, among others, the variations in its orbit, volcanic activity, variations in the output of the energy of the sun, and ocean circulation albedo (National Research Council, 2020; Riedy, 2016). It has been the main driver of biological evolution and ecosystem processes (Falk & Millar, 2016; Inouye, 2022).

Several extreme kinds of weather and climate events are the results of natural climate variability, making natural variability an indispensable influence in shaping future extremes in addition to the consequence of anthropogenic impacts on the climate (Huang & Swain, 2022; IPCC, 2012). Similarly, the issue of concern globally at present is the rapidity in the change of the climate that is propelled by anthropogenic forces. In the last century and a half, anthropogenic forces have led

to the global temperature rise of more than 1°C above the pre-industrial values mainly through land degradation, with the degraded global estimates ranging from less than 10 to above 60 million (Burrell, Evans & Kauwe, 2020; Ortiz-bobea, Ault, Carrillo, Chambers & Lobell, 2021).

The Earth's energy budget is continuously affected (that is, the mean global surface air temperatures over the oceans and the land have increased in the last 100 years) by anthropogenic activities through changes in emissions resulting in the atmospheric concentration of radioactive essential aerosols and gases by changing of the land surface properties (Cubasch et al., 2013; Goosse et al., 2010; IPCC, 2013). Weather factors usually affect regional temperatures, making regions on the Earth experience different levels of warming (NASA, 2020b).

The indirect estimates of the Earth's average surface temperature in about 800 years show that the years 1983 to 2012 were most likely the warmest 30 years experienced (National Research Council, 2020). For example, the average temperature of the United States of America (USA) from 1895 increased by around 1.5°F (0.8°C) and above 80% of this increment happened from 1980, while 2012 was documented as the warmest year when one-third of Americans witnessed about 10 days of 100°F (38°C) temperatures (United States [US], 2014). The average temperature of the year 2019 was recorded and termed by NASA and the National Oceanic and Atmospheric Administration (NOAA) as the second warmest, while 2016 was regarded as the first, making the preceding 5 years the warmest in about 140 years with 1.8°F or 0.98°C warmer above the mean of 1951 to 1980 (NASA, 2020b). Figure 3.6 below depicts the extrapolations of the global temperature anomaly recorded by NASA using its data alongside other temperature statistics such as the Berkeley Earth Research Group, NOAA, Cowtan and Way, and the Met Office Hadley Centre of the United Kingdom which shows an increase in warming with the globe crossing 2°F warming since 2015.

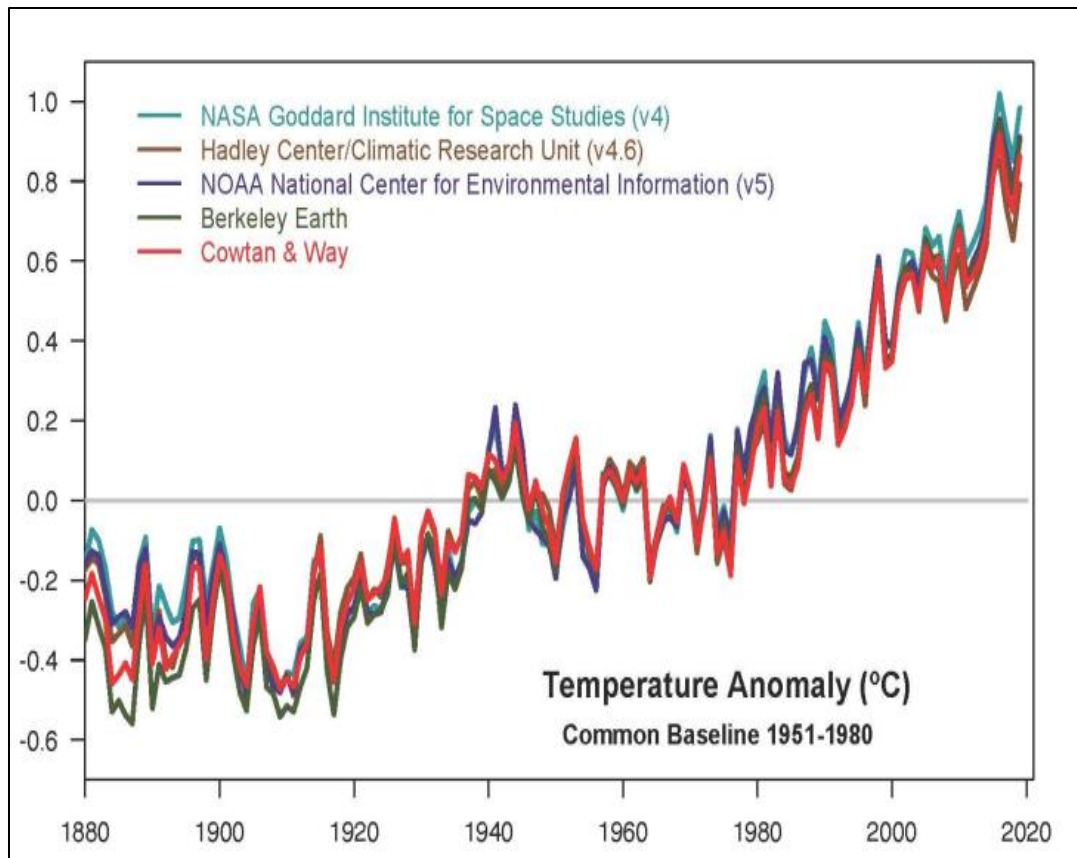


Figure 3.6: Global temperature anomaly from 1880-2020 (NASA, 2020b: 7)

Conversely, the future extent of climate change rests on some variables that include the speed of greenhouse gas emissions, deforestation rates, and ecosystems' responses to the changing climate (Carter et al., 2014). Documented records of global anthropogenic greenhouse gas emissions show that it has been increasing since the pre-industrial age and is driven principally by population and economic growth, with the year 2000 to 2010 having the highest emission values in history at present (IPCC, 2014a; Voumik, Mimi & Raihan, 2023). Weiskopf et al. (2020) observe that the impacts of changing climate are widespread around the globe but are not uniform, with increasing evidence indicating that responses differ as a function of relative vulnerability owing to differences in sensitivity, exposure, and adaptive capacity.

The impacts, consequences, and sometimes the economic costs of climate extremes in different parts of the world can be substantial. For instance, from 1980 to 2019, the USA witnessed about 265 climate and weather disasters, with the cost of damages exceeding US 1,775 trillion dollars

and having an estimated average death of 356 in a year (Ebi et al., 2019). Equally, changing climate is expected to influence natural resources in the world and expected to affect mostly the developing countries (especially the poor countries in the global south) that are regarded as the least contributor to climate change where many people rely on natural resources for their livelihoods (Akanwa & Ngozi, 2019; Maplecroft, 2018a; Thomas et al., 2008; World Economic Forum [WEF], 2021). For example, Africa emits low CO₂ and greenhouse gas, which is currently about 3.8% and regarded as the least contributor per capita terms and absolute to global warming, but is stated to be the most vulnerable to climate change impacts, having a current increase in temperature of about 0.7⁰C with the inundation of its coast and continuous loss of natural resources due to climate change impacts (Ogwu, 2019).

In Africa, climate variability and extreme weather conditions have led to diverse disasters; ecological, social and economic losses; and a projected 118 million poor people in the continent who are living on less than US 1.90 dollars per day are expected to be exposed to floods, drought and extreme heat by 2030 unless adequate responses are put in place (Kuwonu, 2021). The impacts of changing climate were evident in Africa in 2020, characterised by accelerating extreme weather, continued warming, sea-level rise, floods, droughts, landslides and other extreme conditions, including the melting of eastern Africa's last remaining glaciers, which are expected to melt entirely soon, denoting the alteration of the earth system (World Meteorological Organisation [WMO], 2021).

Ebi et al. (2019) and Lund (2019) further maintain that the consequences of changing climate and its extreme events represent major and global socio-economic and political challenges that have the potential to impact almost all industries and livelihoods, strain the infrastructures, and threaten public health. They also state that this makes the world invest millions of dollars yearly for its investigation and initiating necessary procedures to reduce its negative impacts on society. However, climate change is sometimes used interchangeably with global warming, but they are not the same. Global warming is part of climate change that refers to the continuous rise in the average temperature of the planet leading to its overall warming (that is, long-term warming of the Earth) (NASA, 2022; South Pacific Regional Environmental Programme [SPREP], 2014). It is a product of the greenhouse effects on the Earth, which influences other changes in the climate system, including the pattern and frequency of rainfall, and weather event distributions such as

storms, heatwaves, and drought (NASA, 2020b; Riedy, 2016). Accordingly, anthropogenic activities have been estimated to generate around 1.0°C of global warming, which is above the pre-industrial times and a projection of about 1.5°C from 2030 to 2052 if it increases at the existing rate, thus expecting to generate climate-associated risks to nature and humans (IPCC, 2018). As a result, global warming is an indispensable component of climate change. It is, in part, evidence of the changing climate.

Climate change could be defined as shifting climate patterns due mainly to the emission of greenhouse gases from human activities (anthropogenic) and natural systems (Fawzy, Osman, Doran & Rooney, 2020; Ramzan, 2023). Also, climate change and climate variability are tied together as a phenomenon but with distinguishing characteristics. Climate variability is the variations or deviations in the mean state and other features (such as the occurrence of extremes, standard deviations, etc.) of the climate on all temporal and spatial scales outside that of individual weather events (Matthews, 2018). It is the deviations of the climatic statistics over a period which could be a month, season, or year when compared to the long-term statistics for the equivalent calendar period (WMO, 2019).

The fundamental difference between climate variability and change is in the persistence of unusual or anomalous conditions when the events that were always occurring occasionally now happen more often or vice-versa (Drysdale, Moshabela & Bob, 2020; WMO, 2019). Subsequently, scientifically the key difference between climate change and climate variability is in the timescales. Scientists generally use a 30-year minimum base period to track climate (AAS, 2020; WMO, 2019). Therefore, changing climate is unavoidably causing changes in climate variability and the intensity, frequency, spatial extent, duration, and timing of extreme weather conditions and climate events (IPCC, 2012; Thorton, Erickson, Herrero & Challinor, 2014; Roy, Kalambukattu, Biswas & Kumar, 2023). Thus, climate variability leads to deviations from the average climatological values denoting the catalogue of extreme weather events. Ramzan (2023) asserts that weather changes emanating from climate change are global emerging threats and stresses that strain and threaten several world sectors.

Climate variability and change accompanied by localised consequences of rapid urbanisation are increasing the degree of threats to urban settings (IPCC, 2012; IPCC Press, 2022; Mccarthy, Best

& Betts, 2010; UN-Habitat, 2011). Urban changing climate risks are increasing and they include heat stress, extreme precipitation, inland, and coastal flooding, landslides, drought, water scarcity, air pollution, rising sea levels, and storm surges with implications for ecosystems as well as local and national economies (Filho et al., 2018; Li, Sun, Lu, Guo, Wang, Sun & Yao, 2023; Ortega & Canon, 2023; Revi et al., 2014). As more than half of the global community now resides in urban communities, the security of urban spaces will only be assured when the effects of climate variability and change are essentially addressed and ameliorated. Fasona, Ogundipe, Otusanya, Adekanbi & Omuninya (2019) surmise that an understanding of the contemporary and anticipated future patterns in climate systems is indispensable for urban or city environments since it will support and encourage the development and preparation of effective adaptation and mitigation strategies against the impending consequences of changing climate.

3.4.1 Cities, Changing Climate, Biodiversity and Ecosystems

The concept of a city differs in characteristics and features in different parts of the world, with no specific standard criteria to determine its boundaries (United Nations, 2018b). A city is a place where a huge number of people reside that is most of the time a commercial community and probably has a governmental administrative centre. Cities could also be looked at as complex systems that are closely working communities (Bai et al., 2017). Turok and Mcgranahan (2020) describe cities as places that can afford corporations an extensive range of infrastructure and shared services because of their kinds of activities. Ofori-Amoah and Smiley (2023) and Reckien et al. (2017) express that cities are different in economic and political functions, phases of development, climates, and locations. Therefore, in different parts of the world, cities are strategically encouraging the growth, development and strength of their nation. Therefore, they act as the veritable backbones of every nation.

Cities have complex social facets with diverse morals, cultures and ecological entities, having most of the time political control with a distinctive style of human existence (Hall, 2006; Hussain & Imitiyaz, 2019). Cities, being home to about half of the global population, are the drivers of the world economy both in the global south and north countries (Bolay, 2020). Thus, cities are always motivating international economies through their roles in national and regional development while

offering significant opportunities for economic growth and social development with a focal point for employment and innovation, which is a major feature of the advancement of human society (Cohen, 2006; Collier, 2017; Davies, 2015; Gollin et al., 2016; Henderson, Storeygard & Deichmann, 2016; Ofori-Amoah & Smiley, 2023); Ren, Li & Shen, 2018; Shao et al., 2013). Hence, cities and urban areas are expected to deliver livelihood opportunities and social mobility possibilities that are not provided in other places for their residents (Dissanayake et al., 2019).

The continuous increase in the populations of cities is expected to increase their socio-economic and technological advancement, but it also makes the residents have higher demands for its resource, generating pressure on ecosystems which include air quality and watercourses (Grimm et al., 2008; Turok & Mcgranahan, 2020). Bolay (2020) reports that about 70% of the 600 most active cities in the globe are now in the global south countries, where cities in China alone are expected to contribute 30% to the rise in the world's Gross Domestic Product (GDP). In many cities in developing countries, development and economic growth do not always meet the needs of city residents, which leads to increases in poverty, inequalities, environmental problems and health challenges (Kuddus, Tynan, & Mcbryde, 2020; Sun et al., 2020).

Cities are categorised based on their boundaries and, most often, by their population, although sometimes it may be difficult to identify the boundaries of some cities. When the boundary criteria are utilised in city categorisation, we have the city proper. This is solely based on the administrative boundary given by the government, while the urban agglomeration concept of the city reflects the extent of the expansion and increment of the built-up area, and the metropolitan city is identified on the platform of its socio-economic interconnectedness with adjoining areas linked by trade and commuting pattern (Avis, 2019; United Nations, 2018b).

Rapid urbanisation alongside urban growth led to the emergence of large, continuously growing cities in different parts of the world towards the turn of the 21st century, which has, in turn, made the population a criterion in the definition of the city. A new concept that is based only on the population size of the city was coined to categorise big cities. Cities with a population above 10 million are now referred to as mega-cities, which are presently the habitations of about one in eight global urban dwellers (Creutzig & Sethi, 2023; Filani, 2012; United Nations, 2015; Webber, Barnett, Finlayson & Wang, 2018; WEF, 2019). The western mega-cities are key political,

economic and administrative centres in their countries that influence risk negatively and positively, while those that grew rapidly in contemporary years (mostly in developing contexts) are characterised by haphazard construction because of inefficient urban design, poor governance, polluted environments and insufficient infrastructure alongside negative effects on capacity and vulnerability (Kerle & Müller, 2013; Khan, Aslam & Khursheed, 2022).

The world mega-cities include Guangzhou in China, Tokyo in Japan, Jakarta in Indonesia, Mumbai in India, Manila in the Philippines, Mexico City in Mexico, London in the United Kingdom, New York in the USA, Seoul in South Korea, and Lagos (the case study) in Nigeria. The African continent has Lagos (Nigeria), Cairo (Egypt) and Kinshasa (Democratic Republic of Congo) as its documented mega-cities in 2018 and expects two more (Luanda in Angola and Dar es Salaam in Tanzania) by 2030 (United Nations, 2019).

With the continuous urbanisation of most of the mega-cities in the global south, they are not excluded from the incessant proliferation of slums and informal settlements. Such mega-cities include Karachi in Pakistan, Dhaka in Bangladesh, Mumbai in India and Mexico City in Mexico (Ezeh et al., 2017; Khan, Abbasi, Ahmad & Nasir, 2019; Texier-Teixeira & Edelblutte, 2017; Ullah, 2019). Thus, unlike the mega-cities in richer countries in the global north that grew over centuries, allowing time for their infrastructural development, some of these mega-cities grew rapidly, leading to the lagging behind of functional infrastructure for their growing population, which increases the development of informal settlements (Fortin, Gagnon-Dufresne, Cooper, Ferlatte & Zinszer, 2023; Kerle & Müller, 2013). Figure 3.7 below shows the locations of the mega-cities in the world from 2018 to 2030.

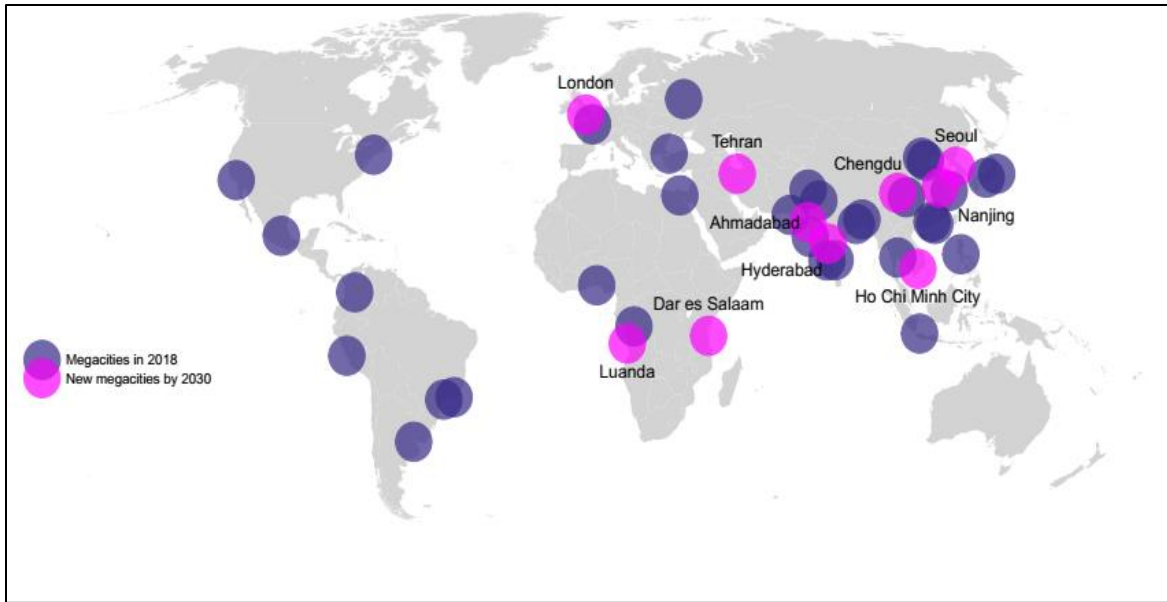


Figure 3.7: World Mega-cities in 2018 and 2030 (United Nations, 2018b: 5)

There were 33 mega-cities in the world in 2018 and they are expected to increase to 43 by 2030, while 27 of the mega-cities in 2018 were located in the global south in less developed regions, out of which China had 6 and India 5 in 2018 (United Nations, 2018b). Similarly, about half of the global urban population inhabits comparatively small settlements of below 500 000 people, while about one in eight people live in 33 mega-cities having more than 10 million residents in different parts of the world (United Nations, 2019). Figure 3.8 below depicts the global distribution of the urban population by the number of cities and different classes of urban settlements based on their number of dwellers. It indicates that as of 1970, there were 227 cities with only 3 mega-cities, while in 1990, there were 412 cities and 10 mega-cities, 2014 had 28 mega-cities and 679 cities and projected 41 mega-cities and 832 cities in 2030.

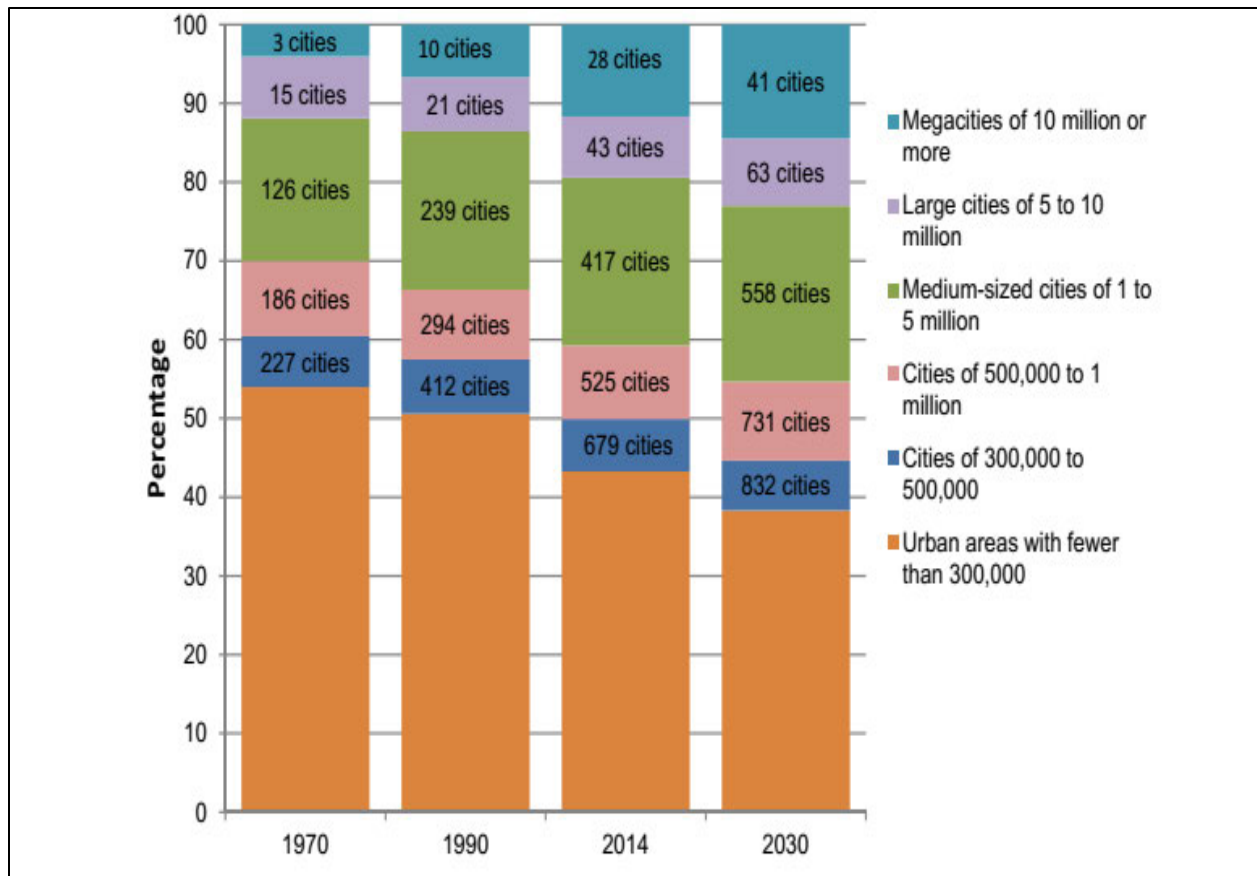


Figure 3.8: Distribution of Global Urban Population by the number of cities and class size of urban settlements (United Nations, 2015: 17)

Rapid urbanisation and changing climate are multifaceted global threats to biodiversity and ecosystem functions and services in cities. This makes them part of the pressing issues of concern in different parts of the world. Ecosystems could be described as the assemblages of microscopic and macro biota that make up the critical life support systems, while biodiversity is the variety or diversity of all life forms in the entire globe, a place, or a particular habitat (United Nations Environmental Programme [UNEP], 2010; van der Geest et al., 2019). Thus, the ecosystem is where groups of living organisms interact with themselves and their non-living components (NGS, 2022c; UNEP/ World Conservation Monitoring Centre [WCMC], 2014). This is on the basis that the achievement of sustainable human societies depends intimately on the successful management of its systems alongside the living components (Malhi et al., 2020). Biodiversity is indispensable in sustaining life and necessary for the supply of ecosystem services (Li, Yu, Huang & Hao, 2022; Organisation for Economic Cooperation and Development [OECD], 2014).

The more diverse an ecosystem, the more resilience it has to cope with different stressors (UNEP/ WCMC, 2014). Schmitt et al. (2019), in their study conducted on tropical forests, revealed that functional diversity improved the resilience of tropical forests after a disturbance. However, the interaction of living organisms with the physical environment subjects them to geographical variations. This interaction also includes the collective effects of diverse pressures, such as overexploitation and destructive land use change, that are experienced in most cities that could be aggravated by changing climate (Prakash & Verma, 2022; UNEP/ WCMC, 2014). Other anthropogenic stressors involved in the modification of ecosystems alongside changing climate include invasive species, pollution and resource extraction (NAS/ TRS, 2019). Previous studies have also shown that ecosystem production and species diversity are determined by geographical variations in seasonality, temperature, and rainfall (Hajek & Knapp, 2022; Thomas et al., 2008). Hence, changing climate has implications on ecosystems via changes in average conditions and alongside climate variability in conjunction with other environmental phenomena such as CO₂ concentrations and increased ocean acidification with other interactions that include defaunation, degradation and fragmentation (Malhi et al., 2020).

Equally, all ecosystem provisions and services, including food and water production, nutrient cycle, crop pollination, and climate control, depend on biodiversity (UNEP, 2010; Weiskopf et al., 2020). The consequences of changing climate, therefore, can directly and indirectly (through harm to natural systems and the ecosystem provisions and services) impact the human system (van der Geest et al., 2019). Subsequently, the loss of biodiversity and degradation of ecosystems can destabilise the provision of the treasured services and provisions of ecosystems culminating in negative socio-economic impacts on humans and related societal components (Crenna, Marques, La Notte & Sala, 2020; UNEP/ WCMC, 2014).

Changing climate is initiating a universal redistribution of life since the geographical distribution of species depends on their environmental tolerance and interactions with other species, and the inability to tolerate the changing climate, shift or adapt tends to lead to the extinction of the species (Pecl et al., 2017). Therefore, it creates large-scale shifts in species abundance, distribution, and reorganisation of aquatic and terrestrial ecosystems (OECD, 2014; Weiskopf et al., 2020). Cubasch et al. (2013) observe that the increased storage of carbon in the ocean, which results from increasing greenhouse gas emissions and pollution, will enhance the acidification of the ocean in

the future and become a potentially grave threat to the well-being of the global ocean's ecosystems. The principal driver of changing climate is CO₂ (Dai et al., 2022; Perera, 2017). Furthermore, marine ecosystems have suffered from elevated water temperature, decreased water oxygen levels, and increased ocean acidity, leading to the loss of about 70-99% of coral reefs (Sinay & Carter, 2020). For example, issues of marine phytoplankton redistribution are expected to have effects on the biological and carbonate pumps of the ocean and subpolar North Atlantic that stores about 25% of the ocean's anthropogenic CO₂ may experience changes in phytoplankton as a result of the ocean stratification strengthening and retreat of the Arctic sea-ice (Pecl et al., 2017).

The unavoidable threats to the worldwide ocean's ecosystems are also subjected to increasing temperatures due to changing climate and other anthropogenic drivers, distorting the livelihood support being rendered by coastal ecosystems to the city dwellers (Morley et al., 2020; UN-Habitat, 2011). Also, several freshwater species are shifting their range of interactions and behaviours with other species (NAS/ TRS, 2019). For example, species may migrate to higher elevations or altitudes where the temperatures are favourable for their survival when there is increased warming, while species tend to die or relocate when saltwater intrudes into freshwater, removing prey or predators that are essential in the prevailing food chain (United States Environmental Protection Agency [USEPA], 2016).

There are also implications of urban growth and development alongside changing climate on coastal city ecosystems. This is because the marine environment that is supposedly rich in diverse organisms has been under pressure from oceanic activities due to urbanisation and coastal activities coupled with changing climate, affecting fisheries and aquaculture that have been a source of healthy nutrition and livelihoods for many residents in coastal communities (OECD, 2014).

The importance of ecosystems to human beings cannot be overemphasised since people depend on ecosystems to provide daily necessities and materials that are needed for regular activities such as recreation, inspiration, mental well-being, protection, and preservation from natural hazards (NAS/ TRS, 2019). Thus, human well-being and survival hinge on nature and ecosystems for the supply of livelihoods. Malhi et al. (2020) surmise that ecosystems can assist in adaptation and mitigation to changing climate and reduce the impacts of climate extremes. The benefits to nature through ecosystem services supplied by biodiversity are essential for the city and urban dwellers'

livelihoods, welfare, and well-being in this urban age. Douglas (2017) affirms that understanding the complexity of urban society and the city is essential in relation to the sustainability of city ecosystems in this changing climate era, as the city's residents may not appreciate many of the services that are provided.

3.4.2 Public Perceptions of Changing Climate and Cities

Public perceptions of risks and consequences of climate variability and change are essential in achieving urban climate security. This is in the vein that changing climate is expected to amplify existing risks and generate new risks for natural and human systems on the African continent (Filho et al., 2018; IPCC, 2014b, 2021; IPCC Press, 2022). Thus, the climate risks are expected to be exemplified in cities and urban environments, which house the largest concentrations of people in the world at present. Hence, urban responses to climate risks are indispensable in achieving sustainable city environments in this changing climate age.

Whitmarsh and Capstick (2018) describe perceptions as an array of psychological constructs that include beliefs, knowledge, attitudes, affect, concern, and perceived risks which are shaped by cultural contexts and social processes. Siegrist and Árvai (2020: 2192) state that perceptions studies are important to understand people's behaviours as well as factors and processes that shape how risks are understood, noting that "the manner in which people perceive risk is important because it influences individual behaviour as well as the acceptance of – and commitment to – specific technologies, policies, and norms". Previous studies show that the perceptions of changing climate are complex and cannot be generalised worldwide but may be culture and country-specific (Lee, Markowitz, Howe, Ko & Leiserowitz, 2015; Reyes-Gracia, Alvarez-Fernandez, Benyei, Gracia-del-Amo, Junqueira, Labeyrie et al., 2023). Hence, the perceptions of urban residents of climate variability and change risks and consequences could be seen as the ways in which individuals who are living in cities respond to the causes of changing climate, its implications, and wider consequences (Capstick, Whitmarsh, Poortinga, Pidgeon & Upham, 2015; van Baal, Stiel & Schutle, 2023). According to Kwon, Kim and Lee (2019), the world focuses mainly on national and local levels to take action in regard to changing climate risks and consequences; however,

sustainable policies will not depend fully on these actions to function maximally but also on individuals' decisions to take laudable approaches as an agent of change.

Individual perceptions of changing climate risks and consequences are influenced by the variability of local weather from time to time when compared to the long-term change in climate, which is significant (Hansen, Sato, & Ruedy, 2012; Ruiz, Faria, & Neumann, 2020). Previous studies by social scientists have demonstrated that risk perception is indispensable in people's responses to hazards (Leiserowitz, 2010; Schneiderbauer et al., 2021). Therefore, public perceptions of the risks and consequences of changing climate will always influence individual and collective climate actions (Sullivan & White, 2019; Hunt, Williamson & Hillis, 2023). Thus, the understanding of the public perceptions of changing climate is critical in building extensive public engagement and development of effective educational and communication approaches that will enhance the development of socially vigorous technologies, and the adoption of acceptable policies that are vital for the adaptation and mitigation approaches for climate variability and change (Whitmarsh & Capstick, 2018).

Since cities are essentially places of innovations, technologies and inventions, urban residents' perceptions of climate issues, which include the imminent risks and dangers, are fundamental to public acceptance, and it stimulates their support for the climate policies alongside encouraging them to put to use the formulated and developed adaptation and mitigation technologies (IPCC, 2022; Leiserowitz, 2006). Similarly, the perception of changing climate issues, risks and consequences vary extensively among individuals and countries, and it is commonly perceived sometimes to be spatially and temporally distant challenges whose risks could be underrated (Fronzel, Simora & Sommer, 2017).

Evidence from diverse surveys conducted worldwide has shown that public perceptions of climate variability and change have continued to increase over the last 30 years and are becoming nearly universal in most of the developed economic nations in the global north, which include the United Kingdom and the USA while it is quite low in developing economy countries in the global south like the Indian subcontinent and sub-Saharan Africa regions (Capstick et al., 2015). The Gallup World Poll of 2007/ 2008, representing a sample of 119 nations, shows that changing climate awareness and perception of risks were unevenly distributed in the world, with over 90% highest

awareness in the developed world (which includes Europe, Japan and North America), while the majority of persons surveyed in developing countries from the Middle East to Asia and Africa reported they had never heard of changing climate (Lee et al., 2015). A study conducted by the Pew Research Centre in 2015 found that the perception that anthropogenic-induced changing climate could signify serious challenges and as one of the greatest threats of that time among many scientists was high with 41% of British, 19% of Chinese, 45% of Americans and 29% of Israelis sharing this perception, while the research also affirmed relatively high scepticism among participants (Raymond, Soutter & Möttus, 2020).

Lund (2019) reiterates that there is a need to enhance changing climate perceptions to encourage policy acceptance and support for adaptation and mitigation strategies in developing economy countries that are known to have weaker socio-economic, political and information infrastructures. Correspondingly, in recent years, the politics and governance in the global south and developing economic countries are transforming into democratic settings from the once autocratic institutions (Stokke, 2018). Capstick et al. (2015) surmise that public perceptions of changing climate are indispensable in this new era since electoral systems play a key role in the initiation and enactment of sustainable policy processes for public and private entities in democratic governance. Sustainable public policy is expected to have inputs from the public for it to be embraced by city residents.

Past evidence in the USA indicates that people's changing climate risk perceptions are always formed through experiences of climate extremes or hazards such as excessive flooding or when participating in individual or collective responses (Sullivan & White, 2019; Hunt et al., 2023). Consequently, programmes and policy thrusts for amelioration, mitigation and adaptation of climate issues and extremes require some degree of individual involvement, which may include attending to policy dictate and expectations of active behavioural transformation (Capstick et al., 2015; Perlaviciute, 2021; Wei, Hansen, Zhang, Li & Liu, 2014). Therefore, building collective individual risk perceptions in cities is essential in eliciting public involvement in nurturing a culture of adaptation behaviour necessary for public support for climate security policy and approaches. In summary, the value of perception-based study in environmental research is that they contribute to promoting societal sustainable environmental behaviours that encourage climate security (Capstick et al., 2015; Hunt et al., 2023; Lund, 2019; Stoke, 2018).

3.4.3 Changing Climate and the Right to the City

The environment will need to be protected and preserved by the people to encourage its sustainability. Environmental rights is a paradigm that expects people to protect and preserve their environment for its sustainability. It is a concept that supports the people to defend nature or its environment from unsustainable use. However, the expected universality of the right to healthy environment cannot be overemphasised (Petra, 2023). At present, achieving the right to a healthy environment in nearly the entire globe may be compromised by the impacts of changing climate and its variability apart from other location-specific environmental challenges in diverse places. On this note, the principles of the right to a healthy environment have been a focus of the United Nations General Assembly and United Nations Human Rights Council in recent years (UNDP, 2023). This is on the basis that human rights are linked to the protection of the environment with obligations that relate to a safe, healthy, clean and sustainable environment (OHCHR, 2023).

The concept of human rights has been promoted through the right to the city to encourage urban preservation and protection with the intent for human comfort and wellbeing (Anguelovski et al., 2019; Tavolari, 2020). The concept of the right to the city came into the limelight through the expression of Henry Lefebvre in 1968. Lefebvre outlined the right to the city as a transformed and improved right of urban residents (Attoh, 2011; Napoletano, Clark, Foster & Urquijo, 2020; Arsian, 2022). Peter Marcuse defines the right to the city based on Lefebvre's expression as a crucial demand by those deprived of existing legal rights and basic materials and the desire for the future by those displeased with life, perceived as limiting their capacities for creativity and growth (Marcuse, 2010; Tavolari, 2020). However, the right to the city has deviated away from the concept of Henry Lefebvre as there is an increased demand to move beyond capitalism and the state with more focus on boosting urban policies and interventions that encourage sustainability, justice and inclusion in the cities (Purcell, 2016; Roulier, 2022). Hence, the right to the city is expected to prevent the city from being reduced to a particular field of discipline and reduced to a setting for conflicts between forces of relations of production and productive forces (Tavolari, 2020). Although the definition of rights may be regarded as varied, vague and open; it is a veritable tool in assisting and illuminating the connections between varying aspirations for social justice and social change (Arsian, 2022; Attoh, 2011). Thus, its principles are essential in ensuring climate

justice through effective management of the multifaceted adaptation procedures that are necessary for climate security in urban areas and cities.

The Habitat III Policy Paper of the United Nations describes the right to the city as the right to security and safety, which emphasises the building of resilience in cities that inspire the coping abilities of urban settlements with sudden shocks such as tropical storms, flooding, earthquakes, and other climate extremes events (Mariño & Rozenblat, 2022; United Nations, 2016a). The right to the city could be regarded as an agenda to evaluate the environmental justice of urban settings (Afrouz & Sajadzadeh, 2021). Issues radiating around urban environmental justice in the developing world and Africa include the impacts of inadequate solid waste management, land degradation, land grabbing, displacement, eviction, deforestation, biodiversity loss, changing climate and climate variability on vulnerable residents and urban informality (Busscher, Parra & Vanclay, 2020; Isgren & Andersson, 2021; Meriläinen, Fougère, Piotrowicz & Fougère, 2019; Parsons, Taylor & Crease, 2021; Wong, 2020). For example, in Dhaka, Bangladesh, the urban poor are always forcefully evicted by the city government from public spaces where they rely on and earn their livelihoods through the engagement of programmes that are expected to promote the global city agenda, denying them their right to the city (Lata, 2021).

The concept of the right to the city is indispensable in this era of climate variability and change since vulnerable urban residents are also predisposed to deprivation, which decreases their adaptive capacities and mitigation approaches. Also, extreme climate events caused by climate variability and change affect the city's population differently and, the measures that are engaged for their mitigation and adaptations (Reckien et al., 2017).

The right to the city is also defined as a process of building cities through declarations of a new style of authority that is based on an assumption of the equality of urban populations with the intent of staging a disagreement among the competing styles of authority (Iveson, 2013). Purcell (2016) maintains that the right to the city emphasises the liberty of the individual to seek protection through establishing a robust distinction between the private and public spheres and grants individuals several rights that are formulated to prevent the limits to their supposed liberty by the state or citizens. The approach to the right to the city has a comprehensive understanding of the prime role that is being played by natural resources and biodiversity in the protection and creation

of favourable living for urban settlements in the face of the challenges that are instigated by changing climate and the management of the city's pollution (Afrouz & Sajadzadeh, 2021; United Nations, 2016a).

There is interest and growth in a diverse range of urban practices that reshape urban spaces. The right to the city is a process that assumes and encourages equality among urban residents. Attoh (2011) and Meriläinen et al. (2019) observe that the right to the city indicates the right to dwell in the city and to produce urban life on new terms and not to be taken away from urban life. Therefore, it is not only about individual freedom to access urban resources but also about transforming the city dwellers by changing the city by exercising collective power that will reshape the mechanisms of urbanisation (Hodson & Marvin, 2009a).

Collective aspiration in cities is promoted by the full participation of the city residents (Broto, Boyd & Ensor, 2015). This decreases discrimination and segregation, strengthening the public's interest in the developmental process and confronting urban challenges, including changing climate (United Nations, 2016a). For example, Shin, Zhao and Koh (2020) argue that the speed of development in Asia was geographical and historical conjunctures that encouraged collective and individual aspirations consolidating present and future development. Some of the resources expected to be mobilised in striving for power include property rights, capital, spatial design, planning codes, law, education, labour, socialisation, policing techniques and technologies (Iveson, 2013). Moreover, collective power is indispensable in the promotion of urban climate security, which is vital for urban sustainability and is key to climate adaptation and mitigation (Broto et al., 2015). Eakin, Parajuh, Anguilla and Yogya (2022) surmise that the perspectives of harms, risks and values in relation to knowledge and understanding of impact are essential in boosting adaptive strategies which are veritable to climate security.

The right to the city is being adopted and used as a rallying point for activism to create support for marginalised societies in cities, while the United Nations Educational, Scientific and Cultural Organisation (UNESCO) and UN-Habitat are using the phrase in expressing policy reforms that will encourage sustainable and inclusive urban development (King, 2018; Purcell, 2016). The principles of the right to the city place well-being as a focus on overcoming multidimensional poverty that is ravaging city dwellers in most of the continuously growing cities in the global south

(United Nations, 2016a). Also, equity concerns are now an indispensable all-embracing global issue that has been documented in the negotiations of UNFCCC towards the course of a post-Kyoto Agreement and incorporated in the SDGs (Reckien et al., 2017).

The right to the city is essentially being adopted as a scheme formulated for the defence of the marginalised and the urban poor whose contribution to changing climate is insignificant, but they are more vulnerable to its impacts (Anguelovski et al., 2019; Arsian, 2022). Scholars and practitioners have utilised the knowledge of the right to the city to work out diverse conceptions of rights, which include immigration, gentrification, citizenship, housing, public space and social exclusion (Attoh, 2011; Da Silva & De Vries, 2022). However, critics and advocates of the right to the city agree that it could be understood in relation to the use of urban spaces with no regard to its market value (King, 2018). The shaping of the spaces in a city is determined by the complex power play in the city as different actors seek to decide what and how the city should be expressed (Iveson, 2013; Da Silva & De Vries, 2022). Hence, the mechanisms and shaping of urban spaces will determine the effects of climate variability and change in cities.

The foundational basis behind the concept of the right to the city is articulated towards justice and equity for every resident in the city (Attoh, 2011; Froese & Schilling, 2019; Global Platform for the Right to the City [GPR2C], 2016; Marcuse, 2010; Purcell, 2016). Thus, Broto et al. (2015), in support of the concept of the right to the city, affirm the importance of equity and justice in building climate security in this changing climate era. This is crucial because the rapid urbanisation that is being witnessed in different parts of the world is accompanied by urban challenges, including water insecurity, food challenges, aesthetics destabilisation, pollution, ecological disruptions and other socio-economic issues (McGranahan et al., 2005; Roberts & Okanya, 2020; Zhang, 2015). Changing climate has the potential to exacerbate and multiply urban challenges (Asaka, 2021; Werrell & Femia, 2015). Therefore, it is a threat multiplier that particularly increases the vulnerability of the poor in cities (Anguelovski et al., 2019). The urban poor are ridden in poverty because of unemployment and insecure employment, social and economic exclusion and lack of alternate housing, which sometimes make them reside in informal settlements and unplanned residential areas lacking adequate services and facilities, increasing their susceptibility to changing climate impacts (Williams et al., 2019). The vulnerability to changing climate and its variability is a multi-dimensional procedure that is affected by social, political and economic forces (Thomas et

al., 2019). The city population responds differently to the effects of climate extremes based on their socio-economic and individual factors (Reckien et al., 2017). For example, flood risk in cities has increased significantly because of the effects of changing climate and its variability alongside socio-economic changes (Hemmati, Ellingwood & Mahmoud, 2020)

Likewise, climate adaptability will be dependent on the mechanisms and shaping of urban spaces (Jiang, Hou, Shi & Gui, 2017). Therefore, the success of climate adaptability procedures depends on the responses of urban residents. Thus, the city stakeholders' willingness and inclinations to cope with the negative implications of climate change depend on the responsiveness and capacity of the change agents, which are the private sector, civil society and government (Carter et al., 2014). However, the power politics in most developing economy cities hinder citizenry equity which is foundational to the right to the city. In the climate variability and changing context, equity and justice concerns arise because of the high tendency for its variability to have more impacts on already vulnerable people and societies since the effects of changing climate do not affect all people equally (Reckien, Lwasa, Satterthwaite, McEnvoy & Creutzig, 2018; Steele et al., 2012). The urban poor populations who contribute to a much lesser extent but are highly vulnerable to changing climate are at most times not involved in decision-making (Ajibade, 2019). The GPR2C is an initiative of organisations that are advocating the implementation of the right to the city as policy and they developed an encompassing matrix defined as a common good that embraces collective rights for inclusive and sustainable cities which emphasises the right to the city as the right of all inhabitants in the city at present and the future (GPR2C, 2016). However, the right of the city is being hindered in different nations, mostly developing economy countries, because of social exclusion programmes that are initiated by the government. For example, Konza Technology City in Nairobi was constructed through a development scheme that was principally a social exclusion approach which is in opposition to the socially inclusive envisioned programme of the New Urban Agenda propagated by the 'Global Platform for the Right to the City' (UN-Habitat, 2020). Figure 3.9 below depicts the right to the city matrix.

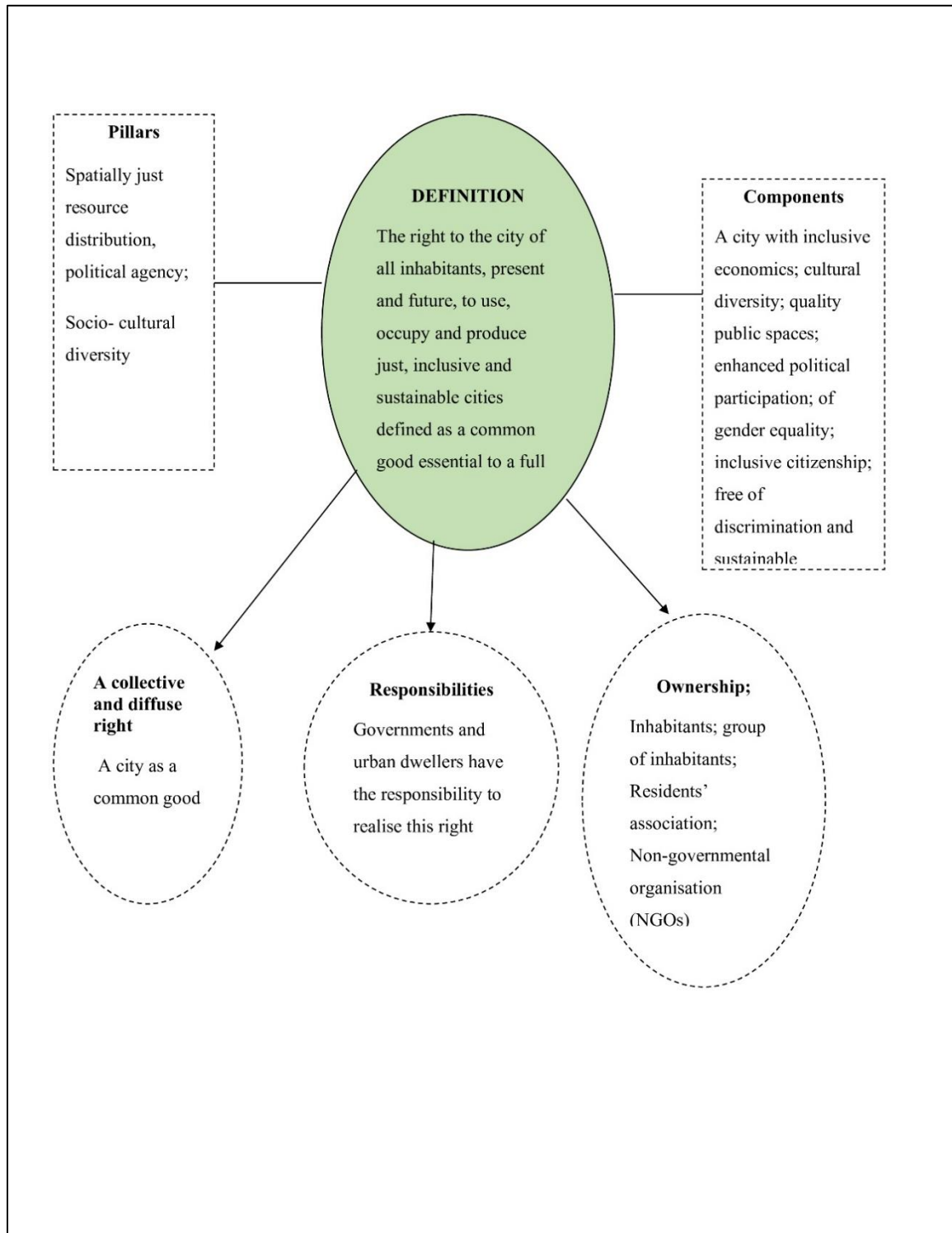


Figure 3.9: The right to the city matrix (GPR2C, 2016: 3)

The right to the city is a distinct and all-encompassing concept because it is not a proposal that is created only by academics nor created by an institution or organisation or political rallying but is an all-encompassing process that may grant understanding of the city laws to its residents, to enhance their well-being (Tavolari, 2020). However, the right to the city of residents is sometimes jeopardised by certain forces such as urban development and transformation. This is coupled with the socio-economic parameters of residents that prioritise and determine the location of urban populations in the cities of many developing countries.

The urban residential location of its dwellers in many developing countries is defined by the socio-environmental amenities, services and infrastructure that are available to withstand and mitigate climate variability and change in urban societies. This is linked to vulnerabilities to impacts of changing climate and extreme events in cities that are connected to urban conditions that include inequalities, poverty, livelihoods, infrastructure availability, and access to services (Broto et al., 2015). Therefore, understanding social responses and the lack of responses to bio-physical changes in society is vital for shaping how humans manage the challenges that changing climate brings to their socio-environmental necessities and economies (Walker, Leviston, Price & Devine-wright, 2015). Power politics are not always socio-politically inclusive, often excluding the locals who are mostly the urban poor that may be ancestrally and socio-economically attached to the city.

The response to perceived changes in the environment sometimes depends on the strength of place attachments (Walker et al., 2015) that influence adaptation to changing climate. Similarly, Groshong, Stanis, Morgan and Li (2020) indicate that place attachment influences people's behaviour to embrace climate-friendly practices and support climate-friendly management actions. Additionally, Dandy, Horwitz, Campbell, Drake and Leviston (2019) indicate that place attachment affects decisions to relocate as a result of environmental change. Subsequently, the successful mitigation and adaptation procedures to changing climate and extreme events in urban centres and cities are expectedly inclusive socio-political processes that must involve every stakeholder. Moreover, a key component being explored in the concept of the right to the city is the potential responses to deprivation in cities (Purcell, 2002; Schuilenburg & Galič, 2020). Thus, the right to the cities can only be achieved in this realm of a globally changing climate when services, amenities and infrastructure that are essential for urban sustainability are provided to every part of the cities. Also, because of the impending challenges associated with changing

climate and climate extremes in this 21st century, the right to the city needs to be constitutionalised by political elites as part of the environmental rights essential to guarantee the protection of city inhabitants (Fraundorfer, 2017). Thus, embracing the concept of the right to the city in urban societies may positively support and influence urban environmental security and encourage the achievement of urban climate security.

A key consideration concerning well-being and the right to cities is access to basic services, which is also indicative of poverty and vulnerability. In relation to energy specifically, Day, Walker and Simcock (2016), Siksnyte-Butkiene, Streimikiene, Lekavicius and Balezentis (2021) and Sovacool and Drupady (2016) assert that access to clean, safe, affordable, efficient and renewable energy services substantially influences the quality of life, livelihood options and vulnerability levels among people. They further note socio-economic activities and livelihoods are dependent on access to energy sources. Additionally, reliance on traditional fuels and/ or mixed energy sources with traditional fuels is referred to as energy poverty, indicative of a lack of access to energy services (Day et al., 2016; Siksnyte-Butkiene et al., 2021; Sovacool & Drupady, 2016). Ogwumike and Ozughalu (2016) and Siksnyte-Butkiene et al. (2021) state that energy poverty influences productivity (also affecting livelihood options) and has health and environmental impacts, including land use change, especially when there is the use of traditional biomass such as fuelwood that can result in land degradation and deforestation.

Furthermore, the updated right to the city principles being advocated by researchers, non-governmental organisations (NGOs), and policy-makers in different parts of the world align with the ideals necessary for the sustainability of the city and the comfort of its inhabitants. Thus, the right to the city emphasises the paradigm for inclusive and sustainable urbanisation due to urban challenges that are associated with rapid urbanisation in Africa, Asia and Latin America, whose cities are donned with poor living conditions, increasing inequality, segregation, environmental pollution and effects of changing climate (United Nations, 2016a). Thus, the right to the city is an essential principle expected to be imbibed in this century when a majority of the global population resides in the city and tends to be exposed to the globally changing climate.

3.5 CITIES AND CHANGING CLIMATE

Cities are known to generate most of the global greenhouse gas emissions, contributing inexplicably to the changing of climate globally and the modifications of the global climate also reciprocate to the environmental challenges that are mostly accompanied by negative implications (Bartlett, Dodman, Hardoy, Satterthwaite & Tacoli, 2000; Choudhary, Kumar & Rai, 2019; Goodess et al., 2021; Grimm et al., 2008; Kerle & Müller, 2007; Kumar, 2021; Moser & Satterthwaite, 2008; Sánchez-Rodríguez et al., 2005). Bai et al. (2018), citing the IPCC, posit that cities generate about 75% of all CO₂ that is produced during energy use. Also, researchers affirm that 40% of global energy used and about 33% of its greenhouse gas emissions are accountable to buildings which are part of the city (Chau, Leung & Ng, 2015; Li, Cui & Lu, 2016; Zhan, Liu, Wu, Li & Wang, 2018). This is apart from transportation and traffic, which are a vital and integral aspect of cities and other cities' conveniences that generate CO₂ (Cong, Saito, Hirata, Ito & Maksyutov, 2018; Creutzig & Sethi, 2023). The anthropogenic CO₂ that is generated in cities is a greenhouse gas that plays an active contribution to global warming, climate variability and changing climate.

Climate variability and change also have negative implications for cities. It is expected to multiply the threats that contribute to the degradation of the environment due to rapid urbanisation and increasing population growth in cities and engendering adverse effects with implications on residents and nature capitals (CNA, 2014; Cobbinah, 2021; Filho et al., 2018; Ogwu, 2019). Cities are specifically vulnerable to the impacts of changing climate because of their location, social and economic inequality, infrastructure, and sometimes the inability to have the power to govern themselves (Cohen, 2019). Thus, the poor, women and other minorities in urban settings are expected to bear the brunt of the negative effects of changing climate because of the uneven distribution of economic and political power (Ferdous & Mallick, 2019; Sorensen, Murray, Lemery & Balbus, 2018; UN-Habitat, 2011). For example, the exposure of women and men in cities may be similar, but women are more vulnerable to climate variability and change because of their heavy household responsibilities, inadequate access to productive resources and sometimes little involvement in expressing adaptive decisions (Owusu, Nursey-bray & Rudd, 2018).

Managing the effects of rapid urbanisation in cities in the context of changing climate is becoming increasingly complex, multifaceted and, at times, largely uncoordinated (Cohen, 2006; Fabiyi, 2017). Consequently, the rapid and continuing urbanisation experienced in cities in most developing countries in this era of climate variability and change may inadvertently generate challenges, including urban conflict and insecurity (Froese & Schilling, 2019; Goldstone, 2002; Okaka, 2014). Similarly, the security components and development antecedents of cities and urban settings are inherently interrelated and interdependent (Spasov & Kastrati, 2021; Wild & Elhawary, 2012).

The security of the urban areas and cities is vital in the determination of their levels of socio-economic development, environmental sustainability, livelihood prospects and physical stability that are expected to be delivered to the occupants. Thus, the threats and implications of changing climate on cities and urban societies may have implications on environmental sustainability with corresponding impacts on sustainable development. Hence, encouraging urban environmental security in cities is indispensable in this changing climate era for the sustainability of urban security, which is vital to state and national security.

3.5.1 Water, environment and changing climate in cities

The importance of water supply for health and well-being as well as livelihoods is well established in the literature (Boadi, Kuitunen, Raheem & Hanninen, 2005; Lin, Ossola, Alberti, Andersson, Bai, Dobbs, Elmqvist, Evans, Frantzeskaki, Fuller, & Gaston, 2021; Livingston, 2021). Furthermore, there is also agreement that urbanisation places increased pressure on African cities where water supply is already strained due to poor and inadequate infrastructure, high demand and limited water supply (Boadi et al., 2005; Lin et al., 2021). **Climate variability and change** have and will, in many instances, worsen this situation (Hope, 2009; Swain, Taloor, Dhai, Sahoo & Al-Ansari, 2022).

The analysis of the water and environment nexus in urban settings and cities is imperative for its sustainability, development and growth. Water security concerns in urban settings and cities could be viewed by examining the wholesome water availability to its human dwellers for sanitation and

consumption, and the threats of water to its environment and human beings through floods and other identifiable ways (Grey & Sadoff, 2007; Sadoff, Borgomeo & Waal, 2017; Mukwirimba, Abdoulahi, Koop, Van Leeuwen, Ovenga, Grekonzy, Ozoani, Marekwa, Hofman, & Berthelot, 2022; Schultz & Uhlenbrook, 2007). It is a twofold nature that considers water as a hazard in case of its threats to livelihood and economic growth through floods, drought and sometimes toxic contamination and as a resource in case of its ecosystems services and provisions, usefulness in agricultural, recreation, and critical for industries (Varady, Zuniga-Teran, Garfin, Martin & Vicuna, 2016; Zadawa & Omran, 2018). So, water security requires a clear focus in the city to ensure effective and sustainable management. Mukwirimba et al. (2022) state that Africa's population growth rate, which occurs mostly in urban areas and is more than double the global average, poses security challenges in sub-Saharan cities. They note that strengthening the capacity of African cities to address urbanisation, climate change and water insecurity requires a focus on "transparent, comprehensive and policy-oriented understanding of the current status of urban water challenges" (Mukwirimba et al., 2022: 182).

Water security includes the identifiable notable threats of water to the city's health security, socio-economic security and urban security. Also, there have been various implications on urban water security because of the concentration of the city's socio-economic activities and the human population due to the imminent climate variability and change capacity to alter the elements of water demand, water availability and water use (Jaramillo & Nazemi, 2017). The implications of changing climate and its variability on urban centres and their water security are key issues in cities because of their dependence on groundwater sources, distances and regional watersheds that are experiencing changes in seasonality, and intensity of precipitation resulting in their landscapes facing issues such as flooding (Hobbie & Grimm, 2020).

The processes of urbanisation are an increasingly indispensable source of competition for demands on water resources, variations in the hydrological cycles and fragmentation of habitats, such as changes in land use functions that may define water availability and hazard risk in diverse contexts while changes in vegetation cover may have effects on infiltration and evaporation which may influence the risk of floods (Romero-lankao & Gnatz, 2016). Also, rapid urbanisation changes city residents' lifestyles from being users of less water to consumers of more water because urban living practices encourage the consumption of water, increasing every growing city's water

demands (Pandey, 2020). Furthermore, the increasing population and socio-economic activities in cities, apart from increasing the demands for water, make the city residents to be susceptible to drought and floods (Pradhanang & Jahan, 2021). Hence, changing climate and climate variability tend to increase threats to water security with implications for city residents (van Ginkel, Hoekstra, Buurman & Hogeboom, 2018).

The United Nations General Assembly and the United Nations Human Rights Council in July, 2010 identified wholesome water availability for drinking and sanitation as human rights (Fantini, 2020; United Nations, 2010). It was further explained that access must be reachable, safe, sufficient and affordable for domestic and personal use (Singh, 2016). This is a far cry in cities in some developing countries where access to safe water has not been possible. For example, there is still a water crisis in Nepal with the proliferation of its water institutions and enactment of water policies that could be ascribed to rapid growth, chaotic urbanisation, changing climate and climate variability that increases pressure on its water security and water resources (Pandey, 2020). Also, Diaz-Caravantes et al. (2020), in their assessment of three cities (Tucson in the USA, Hermosillo in Mexico and Mendoza in Argentina) in Arid Americas, where there is water scarcity, found that with continuous urban growth in contexts where water supply depends mainly on groundwater the cities growth are affective to the health of the aquifers and riparian ecosystems. Hence, water security assessments are indispensable in the development of cities (Mukwirimba et al., 2022), especially with the threats and impacts of changing climate. Thus, it is important in the achievement of urban environmental security. Mukwirimba et al. (2022) specifically highlight the importance of water management priorities in sub-Saharan cities, especially because water security challenges in African cities pose threats to both lives and livelihoods. They further note the need for water management improvement priorities that focus on sustainability imperatives, including waste management considerations.

3.6 NATURE-BASED SOLUTIONS/ RESPONSES TO URBAN CHANGING CLIMATE

The concept of nature-based solutions is created with a foundational knowledge that healthy natural and well-managed ecosystems will produce a wide and diverse range of services that human well-being depends on (Carvalho et al., 2022; Seddon et al., 2020). Thus, ecosystems need to be sustainably managed for humans to enjoy their benefits. Thus, the goal of nature-based solutions is to sustain environmental conditions while supporting social assets and the economy (Eggermont et al., 2015; Stefanakis, Calheiros & Nikolaou, 2021). Thus, nature-based solutions support urban environmental security.

Nature-based solutions could be defined as a process of enhancing nature to solve societal challenges (Seddon et al., 2020; Sowinska-Swierkosz & Gracia, 2022). It is an alternative approach that encompasses predictable, simple and replicable technological strategies to manage the socio-ecological systems in an all-inclusive approach in a way to sustain and intensify the delivery of ecosystem services to the residents of the city (Busayo, Kalumba, Afuye, Olusola, Oloade & Orimoloye, 2022; Eggermont et al., 2015). Thus, nature-based solutions are a nature-inspired process that uses nature to restore the ecology of the cities (Cortinovis, Olsson, Boke-Ol & Hedlund, 2022; Frantzeskaki, 2019). An example of nature-based solutions could be a simple method of utilising native vegetation instead of utilising concrete to control soil erosion and lessen runoff of water across the embankments of the road, and also improving watershed restoration through landscape-scale so as to enhance the availability of quality water in a region (International Labour Organisation/ World Wildlife Fund [ILO/ WWF], 2020; Seddon et al., 2021). Oral et al. (2020) affirm the contribution of nature-based solutions to climate change adaptation in cities by lessening vulnerability to threats by mimicking pre-development hydrological regimes and keeping runoff near its source under the principle of low-impact development and engaging plants to return water to its immediate environment water cycle by evapotranspiration, supporting plants in the dry season. The authors further express that nature-based solutions can also utilise evapotranspiration to contribute to urban cooling by easing urban heat as it supports the greening of urban areas by using local water resources.

Nature-based solutions exceed the traditional approaches of protecting and preserving the environment but consider the enhancement, restoration, co-designing and co-creation of nature with a new green network having attributes of connectivity and multifunctionality (Dushkova & Haase, 2020). It is beyond the typical biodiversity conservation but integrates human well-being, socio-economic development, poverty alleviation and governance (Busayo et al., 2022; Eggermont et al., 2015). Thus, its goal includes the improvement of urban environmental quality and making the city greener and liveable (Dushkova & Haase, 2020). Hence, concepts that are related to nature-based solutions include natural systems agriculture, green infrastructure, natural solutions, ecosystem-based adaptation, natural water retention, ecological engineering and ecosystem-based disaster risk reduction (Eggermont et al., 2015; Kabisch et al., 2016; Sowinska-Swierkosz & Gracia, 2022).

Nature-based solutions are sustainable urbanisation processes that promote urban regeneration through the restoration of degraded ecosystems through the redesign of infrastructure and increasing adaptation and mitigation to risks by utilising nature-based designs that will encourage the reduction of pollution, conservation of biodiversity, reduction of heat stress and promote water retention (Dushkova & Haase, 2020). Also, there is a possibility of incorporating urban agriculture as part of nature-based solutions in the city to contribute to food security and socio-ecological restoration, which is a pathway to climate mitigation or adaptation (Kingsley et al., 2021). Urban agriculture will encourage a decrease in food miles, reducing greenhouse gas production (Artmann & Sartison, 2018). Hence, the focus should be on sustainable or ecologically sensitive agricultural practices that support profitable and environmentally-friendly procedures since unsustainable agricultural practices contribute to negative climate impacts.

The benefits of nature-based solutions require a lengthy perspective and appreciation over time, such as vegetation that grows to become denser and more resilient over a period which is unlike the engineered structures that will always need either maintenance or replacement (ILO/ WWF, 2020). Thus, nature-based solutions can assist cities in the mitigation of negative consequences of changing climate and also provides adaptation options through the promotion of blue and green urban areas with significant probability to reduce vulnerability and also support the resilience of cities to cope with negative impacts (Frantzeskaki & McPherson, 2021; Kabisch et al., 2016; Sowinska-Swierkosz & Gracia, 2022).

The continuous growth of cities such as Lagos Mega-city alongside climate variability and change may decrease the functioning of the ecosystems and the services they provide due to increasing landscape conversion that has become the unavoidable growing threat to urban societies and biodiversity. Nature-based solutions are indispensable in confronting the existential threats of changing climate and its variability with the potential of enhancing social benefits and provisions of sustainable ecosystem services (Stefanakis et al., 2021). Therefore, nature-based solutions may serve as a sustainable response to the growing impacts of climate variability and change in growing urban settings and cities in order to assist in the restoration of the affected urban ecosystems as a means of enhancing the livelihood opportunities of the city residents.

3.7 CONCLUSION

This chapter reviews diverse literature in line with the scope of the thesis as a foundational base for the study. It interrelates concepts of urbanisation, environmental security, environmental management, and environmental geography with climate variability and change. It explores the interrelationship globally, regionally and locally in the context of the case study. It affirms through literature that changing climate and its variability are not new phenomena but a function of the climatic conditions of a place. It establishes that the global concern of changing climate and its variability is its implications on society and the natural environment. It also emphasises that urban societies and city residents are disproportionately affected by changing climate and its variability, especially in developing countries and in poorer communities. This is mostly due to the place and location of their accommodation. This relates to the growing poverty in the city which pushes the poor to reside in informal settlements and slums with inadequate amenities and socio-economic infrastructure that undermine their coping abilities to deal with changing climate.

The chapter also highlights the implications of rapid urbanisation and changing climate on biodiversity and ecosystem functions in cities with prime consequences on the dwellers' welfare and livelihoods, which are indispensable in adaptation processes. It further identifies that public perceptions of the risks and consequences of climate variability and change are important in fostering adaptation and mitigation strategies apart from enhancing the development of sustainable climate policies that are key to climate security. Therefore, the impacts of changing climate may

have implications on the urban environmental security of a city with negative implications on its urban security. This is mostly because of its continuous and unabated population growth, the fragility of its environments, and deficiencies in city planning and management.

The chapter also explores the power politics that is inherent in urban areas and cities, relating it to the concept of the right to the city. It amplifies the right to the city as an inclusive socio-political process that is veritable for the city since it could be part of the process of encouraging urban climate security alongside its urban environmental security. This is through its support of the practice of citizenry equity in cities and the use of collective power to reshape the mechanisms of urbanisation. This is crucial in the formulation of adaptive and mitigation procedures that will encourage and improve the coping abilities of urban societies to the effects of climate variability and change. Furthermore, the chapter also examines the concept of nature-based solutions as a sustainable process that could assist cities in the mitigation of negative implications of changing climate, providing adaptation options, and enhancing social assets and the economy of the residents.

CHAPTER FOUR

RESEARCH DESIGN AND METHODOLOGY

4.1 INTRODUCTION

A research methodology is an indispensable and fundamental part of a study. It is the theory depicting by what means an investigation should be carried out, including the assumptions that are given about the reality of specific phenomena and the ethics and procedures in generating knowledge (Chowdhury, 2019). It is a pathway by which research will be conducted through the development of a research strategy that will enhance the dissemination of results (Cuervo-Cazurra, Mudambi, Pedersen & Piscitello, 2017; Saldanha, 2023; Sileyew, 2019). Thus, the research methodology describes the general process and the flow of the inquiry (Sileyew, 2019). It is the essential principle of research engaged in (Zulfadilla & Caniago, 2021). Thus, it is a process that shows the scientific and technicality of conducting research. It is formulated based on a series of questions designed from the research problems (Gibson, 2017; Gomez & Jones III, 2010; Merchant, Sadaf, Olesova & Wu, 2021). The research questions are used as a guide to organising the data collection procedures, managing the process of inquiry (Harrison, Birks, Franklin & Mills, 2017).

This chapter discusses the approaches utilised in examining the implications of climate variability and change on urban environmental security using Lagos Mega-city as a case study. This study employed a case study tradition for the research because of its effectiveness in the understanding and exploration of complex issues through the examination of data at the micro-level under real global settings, therefore, focusing on and describing the current and prevailing conditions of the study area (Atmowardoyo, 2018; Harrison et al., 2017; Zainal, 2007). Thus, it enhances the engagement of a strong investigation of social phenomena that are occurring in a constrained context (Ruzzene, 2014). A case study describes the procedure of what, how and why something may occur, which leads to an understanding of the importance of the phenomenon being studied (Zulfadilla & Caniago, 2021). This chapter describes the research case study area and clarifies the methodology engaged in the collection of the research data. It explains the analytical procedures

employed for the study and presents the research questions, showing the approaches that were used to deliver the answers to the questions.

4.2 RESEARCH QUESTIONS

The key research questions of the study include

- What are the extent and nature of climate variability and change impacts on rainfall, temperature, flooding, sea level and coastal erosion on urban environmental security of Lagos Mega-city?
- How do climate variability and change affect water security in Lagos Mega-city?
- How has climate variability and change led to an increase in the urban heat island of Lagos Mega-city?
- How has climate variability and change led to a reduction in aquatic livestock of the coastal communities of Lagos Mega-city in Nigeria?
- How has climate variability and change impacted the household livelihoods and well-being in relation to urban environmental security of Lagos Mega-city in Nigeria?
- What are the coping abilities of households and communities to climate variability and change in the context of urban environmental security in Lagos Mega-city?
- What is the policy thrust by the three-tier governments to encourage adaptations to climate change in Lagos Mega-city in Nigeria?

4.3 LAGOS MEGA-CITY: THE STUDY AREA

Lagos Mega-city is a rapidly urbanised setting that is vulnerable to the implications of urbanisation alongside climate variability and change (Adelekan & Asiyebi, 2015; Adeniran, Otokiti & Durojaye, 2020; Adewale et al., 2017; Elias, 2018; Guo et al., 2022; Nkwunonwo, 2017). It is located in the South-Western part of Nigeria and bordered on the south by the Bight of Benin (the Atlantic Ocean), on the west by the Republic of Benin, and in the North and East by Ogun State. Lagos is one of the most densely populated and rapidly urbanised cities in the world, with a projected

growth rate of over 600 000 people in a year (Famuyiwa, Davidson, Ande & Oyeyiola, 2022; Fawode, Nwaogazie & Anyawu, 2023; Ogunbodede, Iweka & Jobi, 2022).

It has a land area of 2 798 km² and a water body of 779 km² (Lagos Bureau of Statistics [LBS], 2017; Wang & Maduako, 2018; Yahaya, Abdulganiyu, Gulumbe, Oladele, Anyebe & Shemishere, 2022). The Lagos lagoon is a large mass of the city where most of the rivers in the southwestern parts of Nigeria drain their water (Yusuf & Abiye, 2019). Also, its southern boundary by the Bight of Benin (the Atlantic Ocean) is about 180 km long (Adeoye & Okeleke, 2022; Durowoju, Olusola & Anibaba, 2017). Figure 4.1 below shows Lagos Mega-city, its local government area (LGA) and its surrounding water.



Figure 4.1: The map of Lagos (Ademola & Abdulkareem, 2019: 2)

Several authors identify the Mega-city geographical coordinates and spatial extension with that of its cosmopolitan Lagos State whose latitude is between 6⁰ 22'N and 6⁰ 52'N while the longitude is between 2⁰ 42'E and 3⁰ 42'E (Durowoju et al., 2017; Soladoye & Ajibade, 2014). However, the Mega-city land space has extended above its metropolitan and cosmopolitan land space of the Lagos State, spreading to the northern and eastern parts of its adjoining neighbouring Ogun State making the city to be referred to as the Lagos Mega-city region. At present, the spatial extent of the Mega-city region has not yet been determined (Wang & Maduako, 2018). It has been extending

to possible directions in the North and West but has been limited by the Lagoon and Atlantic Ocean (Sawyer, 2014). The city is now Nigeria's foremost commercial hub where the main economic activities take place. It is made up of the 20 designated local governments of the Lagos State, which is subdivided into 36 Local Development Centres for its smooth administration. Two of the LGAs (Apapa and Eti-Osa) are also islands that grew to join with the initial Lagos Island. The three islands are presently referred to as Lagos Island.

Lagos is placed as part of the Dahomey Basin in the urban geology of the South Western Nigeria coastal zone, which extends from south-eastern Ghana through southern parts of the Togo and Benin Republic of West Africa region with littoral alluvial deposits that are composed of sand and clay with flat topography that is not too high above sea level with some sets of islands alongside lagoons and creeks (Adegbola, Oyedele & Adeloje, 2016; Davies, 2015; Yusuf & Abiye, 2019). Figure 4.2 below shows Lagos Mega-city in its alluvium geological formation.

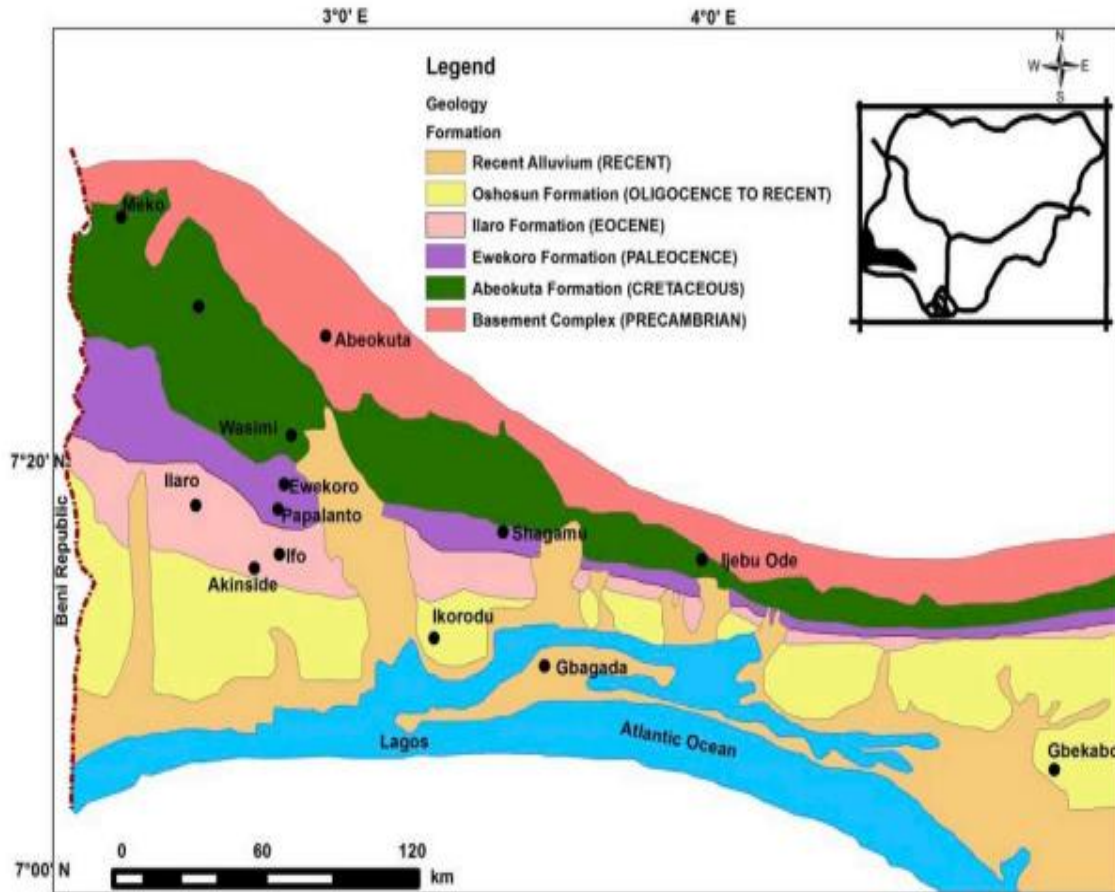


Figure 4.2: Map of the geological formations of Lagos Mega-city and its surrounding areas (Yusuf & Abiye, 2019: 3)

Lagos Mega-city is in the mangrove swamp (coastal vegetation) that extends to the freshwater swamp forest ecological zone. The ecological zones of Nigeria have a temperature range between 24 °C and 32 °C with high relative humidity from 80% to 88% (Davies, 2015; Federal Republic of Nigeria [FRN], 2019). Figure 4.3 below shows Nigeria with Lagos in the mangrove and freshwater swamp zones.

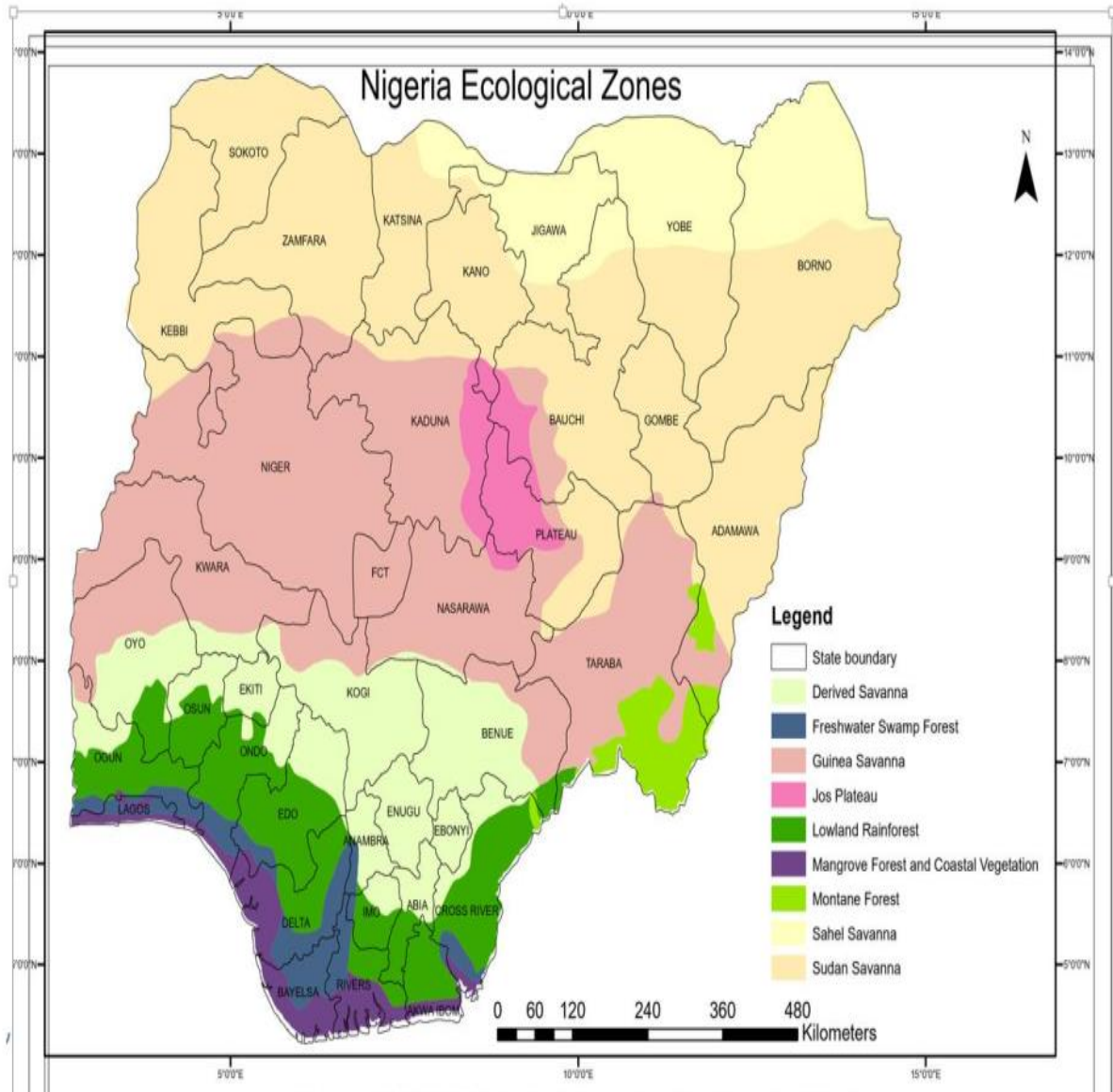


Figure 4.3: Lagos in Nigeria’s Ecological Zones (FRN, 2019: 13)

The southwestern parts of Nigeria where Lagos Mega-city is situated have two main climatic seasons termed the rainy and dry seasons. The rainy (wet) seasons begins from March/ April to September/ October but commonly with a break in August that is termed ‘August break’, while the dry season extends from November to March (Atufu & Holt, 2018; Emekwuru & Ejohomu, 2023; Israel, 2017; Oteri & Ayeni, 2016; Yusuf & Abiye, 2019). The record of Nigeria Meterological Agency (NiMet) from 1985 to 2010 showed that the mean total amount of rainfall per year for Lagos Mega-city was 1 507.4 mm, and the mean monthly amount was 125.62 mm

while 1 802.3 mm (in the year 2002) was the highest and 926.5 mm (in the year 1988) was the lowest (Layi-Adigun et al., 2020). Also, previous studies identify the peak of the rainy season in Lagos Mega-city as June and July (Ayodele & Precious, 2019; Folorunsho et al., 2023; Okoye & Ojeh, 2015).

Historically, the traditional Lagos town was developed from an island called 'Eko', which was coined from the Yoruba Language 'Oko', literally meaning in English farmland, and from the Edo language where 'Eko' was referred to as a camp (Lasisi, 2012; Olukoju, 2018). Later, it adopted the name 'Lagos' given to it by its Portuguese visitors in the 17th century (Bigon, 2011). Therefore, the old Lagos was initially a farm settlement that was mostly occupied by the Awori-Yoruba tribe (Faleye, 2018). The Lagos seaports (including that of Badagry) were used for the slave trade in the later parts of the eighteenth century, which resulted in the city being declared a British colony in 1861 (Olukoju, 2018). Then, the administration of the city was taken over by the British, though Nigeria was still a feudal state that became a country after the merger of the Northern and Southern protectorates in 1914 (Voloshina, 2018). The urbanisation tendencies of the city were stepped up with the European urban policies that supported its administrative position with urban facilities that encouraged commercial activities and boosted the rural-urban drift that attracted a relatively affluent population that supported the consumer market and the development of industrial processes (Emordi & Osiki, 2008).

The trading activities of the colonialist was confined to the city in the early colonial era (Faleye, 2018). Thus, the city's rapid growth was powered by colonial power economies and political administration strategies. The colony became enlarged in 1893 and was converted to a protectorate of Lagos, which made its administrative and political coverage stretch into other parts of the Yoruba Kingdom, leading to enhanced economic activities that necessitated the development of Apapa wharf which afterwards were connected to the hinterland through mechanised road and railway transportation (Olukoju, 2014). This influenced the economic and commercial status of this city, empowering its urbanisation tendency. Also, the culture and the preference of the Yoruba people, who were the main and traditional indigene of early Lagos, to live close to each other explicitly express the reasons for the concentration of higher urban settlements in the city (Farrell, 2018). Therefore, traditionally, the city embraces urbanisation in its early stage, which has been sustained. The city has been a cosmopolitan city since its early days with multicultural and diverse

tribes, which include its main Yoruba tribe, other Nigerian tribes, returnees from African slaves in Sierra Leon (the Saro) and Brazil, and Europeans (Livsey, 2022; Olukoju, 2018). Its primary settlement was about 3.85 km² in 1881 (Durowoju et al., 2017). Figure 4.4 below shows the Eko/ Lagos Island residential area in the 1880s depicting the quarters of the returnees from Brazilians (Portuguese), Sierra Leone (the Saro), the Europeans, and the indigenes (who reside basically in the Isale Eko part of the city).

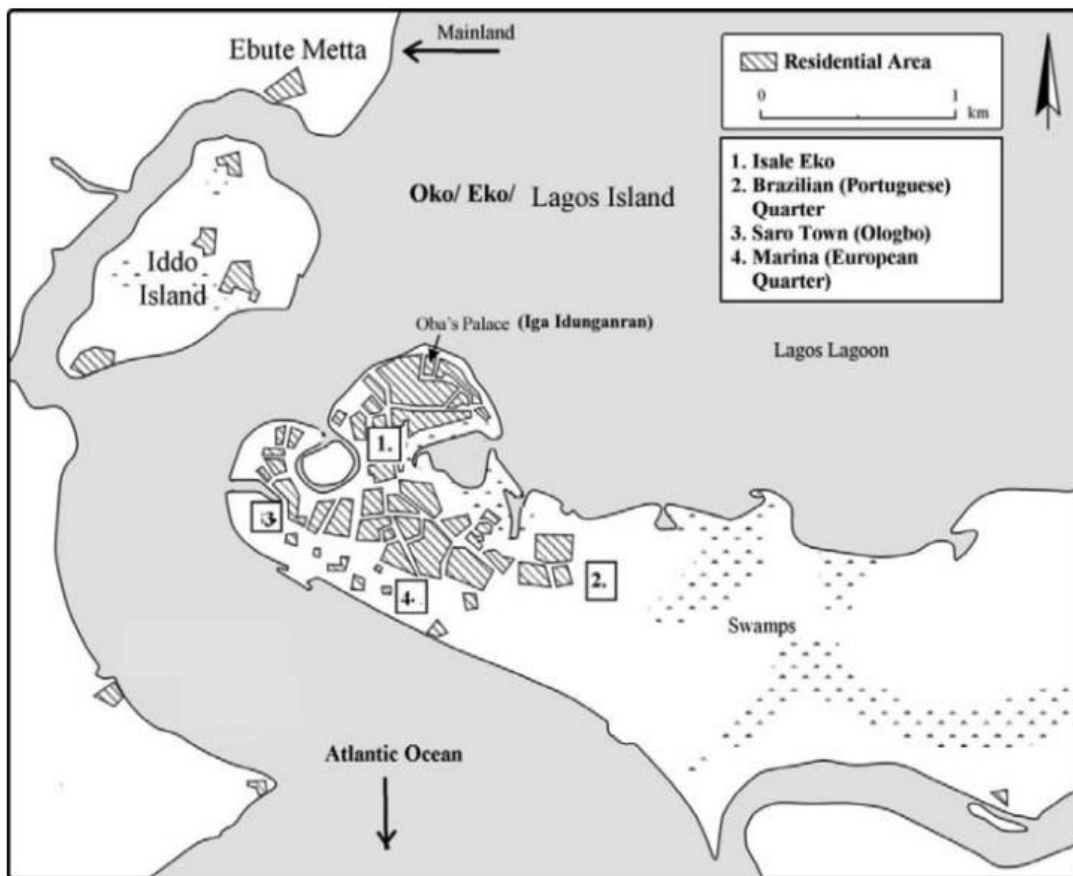


Figure 4.4: Map of Eko city/ Lagos in the 1880s drawn from the British archives depicting the diverse residential areas and its surrounding water (Bigon, 2011: 5)

The city became the first capital of Nigeria in 1914 after the amalgamation of the Southern and Northern Nigeria Protectorates and continued until 1991, when it was shifted to Abuja, though it remains the country's commercial and economic hub. Presently, it has two major airports and four

of Nigeria's eight seaports to drive its business and commercial activities. It is also home to about 65% of Nigeria's industries, 60% of its non-oil economy, and 65% of all its commercial activities (Adelekan, 2010; Adeniran, Stephen & Njoku, 2022; Osanyintuyi, Wang & Mokhter, 2023). Thus, the city is the economic life wire of the nation, having a GDP of 80 billion dollars in 2010, which represented 35.6% of the country's total GDP (LBS, 2015). The indispensable economic abilities and commercial activities of the Mega-city encourage its continuing rapid urbanisation.

As mentioned earlier in chapter one, there is virtually a consensus among researchers that there is rapid urbanisation in Lagos, though there have been controversies surrounding the actual population of the city because of the conflicting census data of the Lagos State government and the NPC of Nigeria (Akiyode, 2010, 2012; Ilesanmi, 2010; Oyegoke, Adeyemi & Sojobi, 2012; Okonkwo & Nnabuko, 2022). The population of Lagos shows it grew to about 700 000 people at the independence of Nigeria in 1960 but has continued to increase rapidly since then (Elias & Omojola, 2015). The records of the Lagos State Government show that the city had 2 050 000 people in 1970, 4 300 000 people in 1980, 7 740 000 people in 1990, 13 400 000 people in 2000, 19 800 000 people in 2010 and 23 040 000 in 2015 (Elias & Omojola, 2015). As of 2012, the Canadian International Development Agency highlighted the growth rate of Lagos as 600 000 people per year, making the city grow more than ten times faster than Los Angeles and New York City (Daramola & Olawuni, 2017).

The official population estimates of the city from the 2018 'World Urban Prospects' gave different population data in its recent time series of the population of the 30 largest urban agglomerations. The time series depicted that the population of the city in 1990 was 5 million people, 7 million people in 2000, 10 million people in 2010, 12 million people in 2015 as well as projected 14 million people in 2020, 17 million people by 2025, and an expected 24 million people in the year 2035 (United Nations, 2019). The rapid population growth and expansion have generated a strong economic base for the city but with negative consequences that include climate insecurity, water insecurity (such as flash floods), biodiversity depletion, and waste management concerns (Muhammed et al., 2017). Figure 4.5 below shows the disparity in the population figures of the city by comparing the estimates of the Lagos State government and that of the NPC official population estimates from 1990 to 2015.

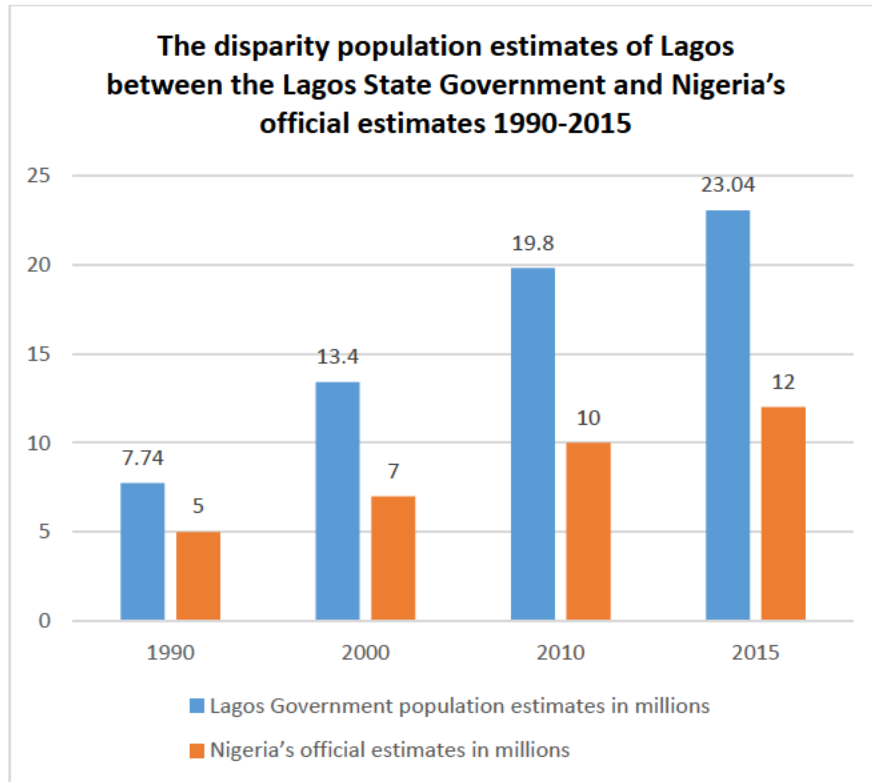


Figure 4.5: Population estimates of Lagos between Lagos State Government and Nigeria's official population estimates, 1990-2015 (Elias & Omojola, 2015; United Nations, 2019)

4.3.1 Lagos Mega-city attributes and urbanisation trends

Lagos is a coastal city that supported commerce and trade in early and post-colonial Nigeria. It served as a link to other parts of the world for the businessmen and women from the hinterland in the early developmental days because of its proximity to the sea and also being the seat of power, making it a centre of business opportunities that was attractive to migrants (Abubakar, Lawanson & Usman, 2020; Lwasa, 2014). Also, the coastal environment of the city is made up of distinctive interphase between the sea and the coast where the lagoon prevents the release of upland rivers directly into the ocean, which creates a typical and subtle collection of ecosystems (Fasona et al., 2019). This also contributes to making the coastline attractive to dwellers.

The roads, railways, airports and other relevant social and administrative infrastructure constructed by the colonialists in different parts of the nation were aimed at achieving their commercial

interests and goals of exportation of resources. Lagos was practically linked to the areas of rich agricultural goods and mineral production as a seaport for export and the seat of the colonial government (Ibrahim, 2014; Sawada, 2018). The policy of centralisation and concentration of government power in the capital city was promoted by the colonialists through the promotion of Lagos as a special harbour city for the exportation of goods from the country (Lohnert, 2017). This process continued up until the pre-independence and post early independence days when the majority of the prime governmental activities and industries were located in the city. Therefore, the rapid urbanisation of Lagos was sustained and enhanced by this strategic urbanisation process that was put in place by the colonial masters during their days which also influenced decisions in the pre-independence and post-independence periods when other relevant and premier social, economic and administrative infrastructure were tactically placed in Lagos as the capital city (Abubakar et al., 2020). However, adequate planning was not put in place by the colonial, pre-independence, and early post-independence governments for the rapid and continuing population growth, which made the city in recent times overstretch its existing facilities and infrastructure (Ajibade & Mcbean, 2014; Ayeni & Akiyode, 2013; Kasim, Wahab & Oweniwe, 2022). Thus, the city metamorphosed during its evolution stages into all the categories of city types proposed by scholars and policy-makers. It transformed from a city proper to a metropolis and then to an urban agglomeration and is now referred to as a Mega-city.

Historically, Lagos was a city proper in pre-independence and the early post-independence period when the city was mainly Lagos Island and its immediate adjoining communities. However, as it grew, it became a metropolitan with a direct influence on adjoining urban areas and towns that were connected to it with transport and commuting facilities from within the Lagos State and its adjoining Ogun State communities (Elias & Omojola, 2015; Oyawoye, 2023). The metropolitan nature of the city enhances its unending growth, making it become an urban agglomeration with spatial and fast expansion that increased its extension and spread in different directions, connecting with other sub-urban and adjoining communities (Obiefuna, Okolie, Atagbaza, Nwilo & Folaye, 2021). Already, the built environment has taken over the land spaces between the city and its adjoining urban centres in Lagos State and the neighbouring boundary communities in the next Ogun State without a visible boundary (Salau, Lawanson & Odumbaku, 2013; Oyawoye, 2023). Presently, the growth of the city has encroached into four of the LGAs of the neighbouring Ogun State (Elias & Omojola, 2015).

Apart from its land spaces that are being overtaken by developments, the trend in the city also indicated that its abundant wetland is fast degrading due to unsustainable use and reclamation without due consideration of its importance in supporting services like carbon sequestration, nutrient cycling, soil formation, and oxygen production, apart from its climate regulatory activities (Agboola et al., 2016; Enoh, Okeke & Nkechi, 2023). The city has overrun its rural communities with structures and constructions that have turned Lagos State into a singular agglomerated city which includes the adjoined neighbouring Ogun State communities to become a Lagos Mega-city Region (Oteri & Ayeni, 2016). Therefore, it is now a megalopolis or a city cluster that grew through the years by agglomerating with other urban centres. Figure 4.6 below shows some of the standing commercial hubs that became parts of the Lagos Mega-city through agglomeration from its initial Lagos Island (that is, Eti-Osa, Surulere, Agege, Ikeja, Ojo, Apapa and Oshodi).

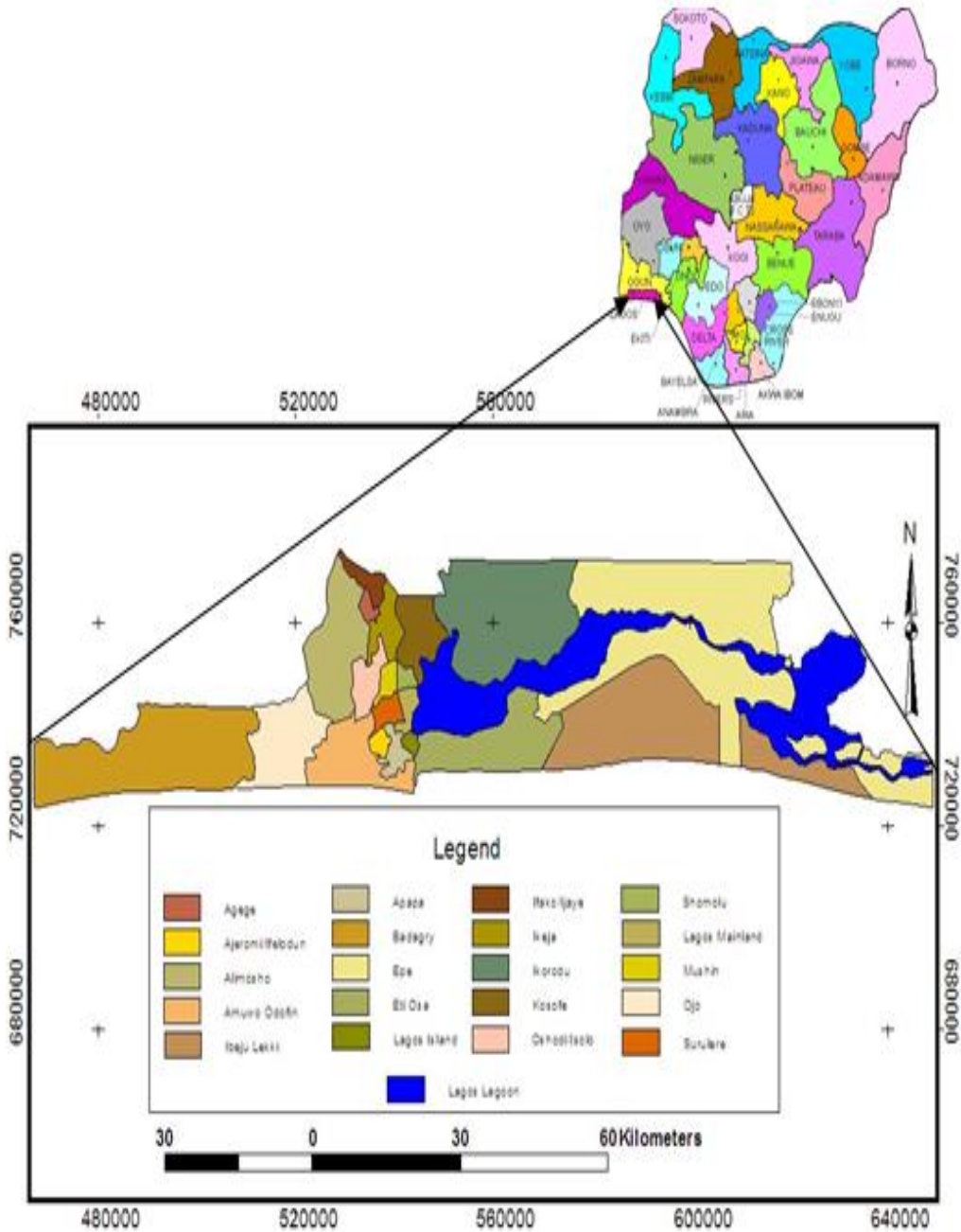


Figure 4.6: Lagos, Nigeria (Ayeni & Akiyode, 2013: 448)

Lagos Mega-city also contributes to changing climate through air pollution from its diverse sources of gas emissions such as the burning of fossil fuel from its industries, power generators, dumpsites, open incinerators, wastes, the use of chemicals and increasing vehicle (cars and commercial buses) use (Komolafe, Adegboyega, Anifowose, Akinluyi & Awoniran, 2014; Punch, 2022). The

transportation sector of Lagos alone contributes about 50% of the greenhouse gas emissions in Nigeria (Maduekwe, Akpan & Isihak, 2020). Also, there are noticeable threats of changing climate impacts in diverse places in the city, which may need an urgent response (Ayeni Omojola, & Fasona, 2016; Elias & Omojola, 2015; Ekoh et al., 2023; Sojobi, Balogun & Salami, 2016).

4.3.2 Water security in Lagos Mega-city

City water security investigation is not only the assessment of the levels of absence or shortage of potable water for its residents but the presence of excesses, such as in the case of flooding, that could be a threat to humans and the environment (Grasham et al., 2019; Grey & Sadoff, 2007). The Lagos Ministry of Environment (LOSMOE) indicated that close to one-fifth (1 403) of the streets in Lagos are susceptible to flooding (LOSMOE, 2014; Ojolowo & Wahab, 2017). Climate variability pronounces the inter-annual inconsistencies, and seasonal changes, alongside the probable frequency of extreme weather-related events in water insecurity which include floods and droughts (Umar et al., 2019; Zhao, Zhu, Liu, Pan & Zuo, 2016). Similarly, the impact on water security may affect the security of lives and properties, especially with the apparent changes in the global climate (Adams et al., 2022; Zadawa & Omran, 2018). Water insecurity in the case of floods and drought has been a recurring condition in many cities in developing economies. Thus, examining urbanisation impacts and influences on water, environmental security, and the threat to lives and properties in developing countries' growing cities is imperative and essential to its security and sustainable development.

Population growth and economic development are naturally associated with an increase in demand for water (Hoekstra, Buurman & van Ginkel, 2018; Lundqvist, Apassamy & Nellyyat, 2003) and any urban growth that is not anticipated nor sustainably prepared for may have negative consequences for households' water security. Thus, households' domestic consumption or water insecurity in some of the cities in developing countries in the global south is an issue of concern. Such cities in the global south that have consumption and water insecurity challenges include Mexico City in Mexico, Jakarta in Indonesia, Kinshasa in Congo and most of Nigeria's big cities (Bédécarrats, Lafuente-Sampietro, Leménager & Lukono, 2019; Pacheco-vega, 2019; Stoler et al., 2020; Titisari, Maheshwari & Hagare, 2019). Also, Lagos Mega-city has experienced at different

times perennial potable water shortages for its residents because of continuous institutional challenges and infrastructural decay (Akoteyon & Otusanya, 2023; Aliu, Akoteyon & Soladoye, 2021; Ayeni & Akiyode, 2013; Biswas, 2022; Demehin, 2022). The daily domestic water demand in Lagos is 540 million gallons per day (MGD), and the production capacity by the Lagos State Water Cooperation is at 210 MGD, which creates an acute shortage that affects mainly low-income people and compounds public health and sanitation concerns (Akinbode, Jakpor, Bohme, Kishimoto & Lobina, 2016).

In a recent study by the British Natural Environmental Research Council (NERC) in Lagos, it was affirmed that individual water supply augments the domestic supply in Lagos, making about 68% of its residents use private boreholes daily, 41% use shared boreholes daily while 17% source water through open wells at least once in a week and 95% use bottled/ sachet water every week (Upton et al., 2019). The large volume of groundwater is abstracted from the Lagos multilayer aquifers to supplement its daily needs, which has been found to lead to the gradual decline of its water table even with its potential recharge by the high rainfalls of the city (Shiru et al., 2019). Also, water through excessive flooding has become a continuous threat to lives and properties every year in Lagos Mega-city and some other continuously growing cities in developing countries. Furthermore, Lagos Mega-city is located in a natural harbour that is afforded by lagoons whose significant parts and hinterlands lie at or below mean sea levels and estuaries and have a nature that is traditionally alluvial with dunes and other formations that make it sustainable to erosion (Oloyede, William, Ode & Benson, 2022; Simon, 2010).

Wahab and Ojelowo (2017), in a study on flooding experiences in Lagos, inferred that the earliest recorded flooding events in Lagos in 1947, 1974, 1994 and 1995 did not claim any life, but only destroyed properties because of its inconsequential spatial and demographic size with lesser development on the floodplains. They also surmised that there has been increasing destruction of properties and loss of lives during excessive flooding since 1996, when greater parts of the floodplains have been occupied with built environments (Wahab & Ojelowo, 2017). Image 4.1 below is an example of a flash flood that was witnessed in Lagos after torrential rain in 2020.



Image 4.1: Example of flooding in Lagos after torrential rain (Vanguard News, 2020a)

The location of the Lagos Mega-city makes it fragile, susceptible and vulnerable to the negative impacts of water insecurity, especially in this changing climate era (Adegun, 2023; Lawanson, 2016). Ibeabuchi (2023: 50) states that in Lagos metropolis the frequency of heavy rainfall and flood risk events has increased between the late 20th and early 21st century, and that “it is more likely than not that there has been a human contribution to this trend due to its low lying topography (between a slope of 1 and 1.630)”, urbanisation, socio-economic activities and the population size. The topography of Lagos is low-lying, with typical slopes of 1-4% having elevation ranges from or below sea-level to about 2 m above sea-level (Atufu & Holt, 2018; World Bank Group, 2019). Records have shown that more than 3 million people reside in the low-lying parts of Lagos Mega-city, which are characterised by inadequate infrastructure (French, Awosika & Ibe, 2011), while more than half of the population of Lagos Mega-city resides in less than six feet above sea level (Enete, Officha, Ezezue & Agbonome, 2012). This low-lying coastal line nature of the city predisposes it to sea-level rise. Globally, different parts of the world are expected to experience an increase in sea level rise due to climate variability and change in the 21st century

when compared to the last century, which could engender flooding, loss of habitats, salinisation of groundwater and surface, and degradation of coastal wetlands (Hanson, Nicholls, Hallegatte, Corfee-Morlot & Chateau, 2011; Siegert, Alley, Rignot, Englander & Corell, 2020).

Lagos Mega-city is also identified as one of the ten cities in the world expected to face high risk from the impacts of climate variability and change (Maplecroft, 2018b). Moreover, Lagos Mega-city has a trend of increased frequency of inland and coastal flooding that results from increased intensity of rains annually (Adelekan, 2010; Adelekan & Asiyebi, 2015; Fasona et al., 2019; Kabat & van Schaik, 2003). It is also placed fifteenth in the assessment of the top twenty cities ranked in terms of the population exposed to coastal flooding by 2070 in climate and socio-economic scenarios (Adegun, 2023; Hanson, Nicholls, Hallegatte, Corfee-Morlot & Chateau, 2011).

Aniramu, Orimoogunje, Ojimadu, Odelola and Okebugwu (2023) also noted that changes in weather elements have devastating effects on lives and properties within a built-up environment. They used daily climatic data obtained from the Nigerian Meteorological Agency to provide a realistic simulation of rain-fed flooding in Lagos. The results indicate significant relationships between high rainfall trends and flood occurrences as well as associated flood events in some months of continuous stormwater. Furthermore, Aniramu et al. (2023) assert that flood hazards associated with extreme weather have increased in frequency and severity in recent times.

Recurrent flooding may be associated with sea-level rise, which is an implication of changing climate (Adegun, 2023; Adelekan, 2010; Adelekan & Asiyebi, 2015; Dolan & Walker, 2006; Hanson et al., 2011; Nicholls, 2003; Nicholls et al., 2007) and has been acknowledged as a significant threat to sustainable development in the Mega-city (Lagos State, 2004). Also, agricultural practices along the coastline face added consequences and risks from increasing sea-level rise, seawater intrusion, storm surges, rising salinity and flooding that are common to changing climate apart from the rapid urbanisation stress (Gopalakrishnan, Hasan, Haque, Jayasinghe & Kumar, 2019). This may tend to impact negatively on food security and human livelihoods apart from increasing the rate of unemployment in these cities.

The analysis of the rainfall of Lagos for the period 1971-2005 shows that rainstorms have been heavier even though the number of rain days reduced (Adelekan, 2009; 2010). Records show that

the mean annual rainfall for ten years between 1996 and 2005 was 1 647.26 mm while that of a period of 25 years between 1971 and 1975 was 1 697.79 mm (Adelekan, 2009). In the year 2020, NiMET predicted a near-normal rainfall for Lagos Mega-city and some parts of the southwest of Nigeria with the expectation that rainfall will be witnessed between 240 and 270 days (The Lagos State, 2020; NiMET, 2020; Vanguard News, 2020b). The organisation also expected a mean rainfall between 1 526 mm and 1 730 mm in the Mega-city. With this prediction, the government expects flash floods in some areas and has put in place emergency flood abatement procedures, and has also provided pumping stations for anticipated flooded areas to ensure rapid pumping out of the water to reduce risks to life and destruction of properties during flash floods (Vanguard News, 2020b).

Generally, vulnerable areas of Lagos Mega-city are predisposed to flooding with the inadequacy of city drainage systems in most of the flood-prone areas and increasing rain intensity (Douglas et al., 2008; Ekoh & Teron, 2023). Moreover, continuing rapid urbanisation in the city makes natural surfaces be replaced by structures and concrete surfaces and roads, which hinder the percolation of water to the ground, encouraging flooding (Adelekan, Johnson, Manda, Matyas & Mberu, 2015; Cirella & Iyalomhe, 2018; Israel, 2017). Similarly, past experiences in Lagos Mega-city have shown that torrential rains that fall consistently for about 8 hours permit flash floods due to the inability to effectively discharge into Lagos lagoon due to the rise in ocean level linked to changing climate (Vanguard News, 2020b).

The Lagos Island area, which stands as the prime commercial and economic centre of the Lagos Mega-city, has few available land spaces for city development. This has resulted in some city developers' sand-filling some of its wetlands and converting them into residential areas. This includes its neighbouring urban areas such as Ikoyi, which was developed from an area that was initially covered by 60% wetland, while the adjacent Victoria Island and Lekki were formally in the low-lying barrier lagoon systems interspersed by wetlands and tidal flats with an elevation of about 0-3 meters before development (Mehrotra et al., 2009). This has made the areas to be susceptible to flooding since the natural purpose of the wetlands, which includes flood control, has been hampered. Coupled with the continuous sea-level rise that is due to the changing climate that is experienced in the West African coastline, the threat of water security in this climate variability and change era through flooding is affecting the sustainability of the security of Lagos Mega-city.

Generally, water insecurity in the event of flooding has led to mishaps at different times in the city, even though the scientific documentation of these negative impacts is not adequate. The devastation of flooding could be more pronounced on the poor in the city and the disadvantaged population who live in low-lying areas, swampy lands and flood plains that are characterised by inadequate resources, social protection and necessary information, which are crucial to mitigate their increasingly hazardous situations (Ajibade & Mcbean, 2014; Ekoh & Teron, 2023).

The incidence of flooding caused by heavy rainfalls in the Lagos Mega-city has led to the loss of lives, displacement of people and enormous economic loss of millions of Naira (The Georeferenced Emergency Events Database [EM-DATA], 2014; Federal Ministry of Environment [FME], 2012; Nkwunonwo; Roa, 2022; Whitworth & Baily, 2016). For example, in the main section of the Mega-city, 25 people died in July 2005, while 20 people lost their lives in Lagos Island, Apapa, and Kosofe areas of the Mega-city in October 2010, 16 people were swept away at the Victoria Island by the surge of the Atlantic Ocean in 2011 and above 50 people also died in October 2012 (EM-DATA, 2014; FME, 2012; Nkwunonwo et al., 2016; Stark & Terasawa, 2013).

4.3.3 Climate variability and change, human livelihoods and urban poverty in Lagos Mega-city

Sustainable human livelihoods are the expectation of every society. This infuses vibrancy and resilience among the populace and enhances their capacity to cope in the case of an impending threat such as changing climate. Olajide et al. (2018) surmise that there is a huge amount of livelihood research globally that indicates its multidimensional nature covering a varied aspect of the human enterprise, including the intention and process of alleviating people's poverty. Therefore, the condition of human livelihoods in an urban environment context will contribute to residents' well-being and their coping abilities with the city's fragilities and extremes, boosting the levels of urban human security. The importance of adopting SLF and SULF approaches was highlighted in the theoretical framework for this study.

Human livelihood opportunities can be affected by changing climate in cities (Behnassi, 2017; Orimoloye, Mazinyo, Kalumba, Ekundayo & Nel, 2019). Changing climate induces and

exacerbates livelihood vulnerabilities in urban areas and cities by reshaping their exposure to hazards and risk dynamics, creating a negative undertone to their coping and adaptive responses (Dodman, et al., 2023; UNDP, 2013a). Therefore, strengthening the approach to sustain the city's human livelihood capacity will enhance human advancement and development. Unfortunately, the urbanisation trends in most of the continuously growing cities in the sub-Saharan African countries, including Nigeria as shown earlier, is a complex and dynamic process accompanied by diverse consequences for humans and environmental survival that may either discourage or encourage socio-economic growth (Cobbinah et al., 2015; Zu Selhausen, 2023). An unplanned urban centre or city with inadequate economic opportunities for most residents threatens its sustainability and security (Grob, Papadovassilakis, Ribeiro & Vicente, 2016).

Changing climate and its extreme events interact with the adaptive capacities of the urban poor, influencing negative implications on their livelihoods (Adegun, 2023; Ekoh & Teron, 2023; UNDP, 2013a). Thus, the propensity of changing climate makes poor communities located in vulnerable conditions such as flood plains experience exclusion of livelihoods and multiple deprivations (Ekoh & Teron, 2023; Olajide & Lawanson, 2014). Also, the designed adaptation and mitigation to changing climate and its extremes expected to be implemented in urban areas and cities may have effects on vulnerable urban residents when not planned with the consideration of the differential levels of residents' coping abilities, capacities and resources since changing climate threats, impacts and risk affect urban populations differently (Reckien et al., 2017).

Lagos Mega-city is a continuously growing, economically thriving and buoyant city that has a large population of poor residents (Adelekan, 2016). Also, it has no adequate safety nets that will cushion the increasing hardships experienced by its poor residents. The founders and early settlers were farmers before the city transformed into a commercial and economic city as it continued to grow from the early colonisation age to the independent period (Akinpeju, Nwokoro & Aluko, 2022; Lasisi, 2012; Olukoju, 2014). However, food production in this continuously growing city is currently being limited because lands are mostly taken for industrial, public, commercial and residential uses that leave farmers to plant in marginal properties (most times leased land) that are prone to flooding (Odudu, 2015; Okundaye, Aigbe, Ogbolu, Tzortzopoulos & Gao, 2022; Shonde et al., 2023). Thus, food or agricultural production has been limited in the city. This has negative consequences on the urban poor and the city's food security. The proximity of the city to the

coastline of the Atlantic Ocean and its water environment (the Lagos lagoon) also made fishing a prominent traditional livelihood of the initial residents. This has been sustained by the descendants of the early fishmonger settlers residing around and on the lagoon. However, changing climate has been documented to affect the growth and migration patterns of fishes due to rainfall levels, temperature and hydrology, whose parameters govern the abundance and availability (Adewale et al., 2017). Thus, climate extremes, with their associated impacts on coastal erosion, flooding and destabilisation of the aquatic ecosystem, have reduced fish catch with untold impacts on the fishers' incomes and their dependents, invariably leading to unavoidable adverse impacts on the well-being and livelihoods of the fishmongers (Fakoya, Oloko & Harper, 2022; Omitoyin & Tosan, 2012; Roa, 2022).

The Mega-city LULC patterns have been changing because of rapid urbanisation (Sunday & Ajewole, 2015). In a comparative Geographical Information System (GIS) study that was based on Operational Land Imager (OLI), 2013, Enhanced Thematic Mapper Plus (ETM+) 2000, and Landsat Thematic Mapper (TM) 1984 on Eti-Osa area of the city from 1984 to 2013, it was found that the built areas of the community increased by 973.63 hectares while 6 717.65 hectares of mangrove, 1 740.49 hectares of water bodies and 1 314 hectares of wetland were lost to reclamation during the same period (Adegboyega, Oloukoi, Olajuyigbe & Ajibade, 2018). Also, there has been a continuous loss of massive and extensive wetlands, floodplains, swamps and mangroves that would have been acting as buffers for floods that occur due to the reclamation of land and climate variability and change (Enoh et al., 2023; Idowu & Home, 2015).

The urbanisation trends continue to deplete ecosystems that have naturally provided for the sustenance of human livelihoods. This is expected to be compounded by the increasing impacts of changing climate (Firn et al., 2015; González-Orozco et al., 2016). Hence, the continuous depletion and loss of ecosystems in the city may have indescribable impacts on human livelihood opportunities that the city residents, mostly the poor, would have depended on for their survival. Olajide et al. (2018) indicate that the execution of the Mega-city development projects and the urban policies were working against the poor, enhancing hardships through a continuous decrease in human livelihood prospects.

4.3.4 Slums and informal settlements development, climate variability and change in Lagos Mega-city

Slums and informal settlements are not the same but have resemblance in characteristics and features, although there has not been a consensus on the actual definition and description of slums by experts. However, it is an indication of deficiency in housing and the relative inability to pay for formal housing (Badmos et al., 2020; Roberts & Okanya, 2020). The Global Development Research Centre (2024) states that slums refer to urban settlements that are congested and characterised as deteriorated, unsanitary, prevalent poverty and social disorganisation (focusing on the environment and quality of life), while squatter settlements refer to communities where residents settle on land (especially public or unoccupied land) without permission from the land owner (focusing on the legality of occupation). Informal settlements are located not following the laws and regulations that bind land use, construction of buildings, infrastructure, and the provision of services (Satterthwaite, Archer, Colenbrander, Dodman & Hardoy, 2018).

Slums and informal settlements are often products of deficient urbanisation. Sustainable urbanisation is associated with a city that provides consistent and sufficient revenues which support and encourages the generation of decent employment for its dwellers, supplies adequate infrastructure and amenities for its residents, preserves the health and environment of its inhabitants, and respects justice and equity for its populace (United Nations, 2019). Thus, the slum is an expression used as a basis for measuring the quality of housing, overcrowding and availability of urban services, while informal settlements are inhabitants that contravene specific laws and regulations (Satterthwaite et al., 2020).

The proliferation of slums and informal settlements in cities of low and middle-income countries is due to pressures of in-migration, high birth rates and the non-availability of formal structures that will absorb the speed of urbanisation (Roberts & Okanya, 2020). Also, public interventions for rapidly urbanising cities in most African countries do not keep pace with the demand for land and shelter (Bolay, 2020). However, past evidence has shown that differentials in risk arise from none or inadequate services and infrastructure in informal settlements of some cities in developing countries (Reckien et al., 2017). Subsequently, the growth and proliferation of slums are encouraged because the development measures, which include social services and infrastructures,

are not keeping pace with urbanisation and the rate of increase in population in many cities in developing economies (Farinmade et al., 2018). Thus, they are mostly unplanned residential areas that are typically direct products of uncontrolled urbanisation that are usually found in some of the cities in the global south, with the occupants mostly having no legal claim (Williams, Costa, Sutherland, Celliers & Scheffran, 2019). However, for about two decades now, there has been an improvement in urban slums in some parts of the world through strategic movements of millions of people from substandard accommodations to adequate housing, making global urban residents in slums from 2000 to 2014 decrease by 20% (United Nations, 2019).

The slum populations as per the most recent data (2014) classification based on the world economies was 68% of the urban population in lower-income countries, 33% in lower-middle-income countries and 23% in upper-middle-income countries, while there are no slums in higher-income countries (World Bank Group, 2020). **Table 4.1** below depicts the slum population as a percentage of the urban population based on the world economies.

Table 4.1: Slum Population (Percentage of Urban Population) based on World Economies

World Economies	Slums Population (Percentage of Urban Population)
Low-income economies	68
Lower middle-income economies	33
Upper middle-income economies	23
High-income economies	None

Source: World Bank Group (2020)

It was estimated that about 1 billion people are presently living in slums which are expected to double by 2030 (Ezeh et al., 2017; Satterthwaite et al., 2020). The slums and informal settlements proliferation in cities in developing economies and the global south are basically due to a lack of adequate planning for city growth and expansion (Adelekan, 2010; Farinmade et al., 2018). Hence, slums and informal settlements grow alongside rapid urbanisation in some of the growing cities in developing countries, like Lagos Meg-city, increasing the distortion of their urban environmental security.

Slums and informal settlements with their prevalent poor populations are vulnerable to the negative implications of climate variability and change because of the fragility of their environment and inadequate land management (Revi et al., 2014; Sterzel et al., 2020; Williams et al., 2019). Hence, it has been revealed that several informal settlements grow in fragile and hazardous places to meet other needs, such as access to jobs and financial challenges (Satterthwaite et al., 2020).

The nature of the slums and informal settlements, with the insecurity of tenure, informal legal status and limited access to basic services and facilities, increase residents' vulnerability to extreme events due to changing climate (UNDP/ UN-Habitat, 2013). The environmental risks that are confronted by slums and informal settlement dwellers are connected with the social drivers of vulnerability, including low income alongside gender discrimination (Satterthwaite et al., 2020).

Slums and informal settlements are also common in growing big cities in Nigeria, such as Lagos Mega-city, Port Harcourt, Ibadan, Kano, Enugu and Benin. The slums and informal settlements exist with a persistent gap between resources and demand for housing (Gbadegesin & Aluko, 2010). There has been laxity on the part of the Nigerian government in controlling the growth of informal settlements in most of its cities (Badmos et al., 2020) related to the sloppiness in the enforcement of the planning laws and policies that have contributed to the growth of slums and informal settlements in some of Nigeria's cities.

The challenge of housing for the continuing growing residents of Lagos Mega-city has contributed immensely to the growth of slums and informal settlements in the city. Lagos Mega-city has an acute housing shortage for its middle and low-income earners, which makes the city have a deficit of 5 million houses which accounts for 31% of the Nigerian deficit of about 18 million houses (Lumumba, 2016). Also, the urban growth witnessed was not accompanied by sufficient industrialisation that will absorb the in-migrants, leaving the majority of them in the informal sector, which is mostly situated in the slums and informal settlements (Lohnert, 2017).

The in-migrants of the city adopted different forms of informal processes that are not in compliance with the city's physical planning control and development regulations to provide shelter and accommodation that are resulting in the growth of squatters and slums (Nwanna, 2018). Also, most of the building construction in the slums and informal settlements is carried out without obtaining permission from the local government and the city government as prescribed by the law, making

their land illegal and contested (Satterthwaite et al., 2020). For example, in 16 local governments of the Lagos Mega-city between 2011 and 2013, 3 647 buildings contravened planning laws, and 578 were demolished (Wahab & Ojelowo, 2017). Table 4.2 below depicts the number of building contraventions and the number of buildings demolished in 16 local governments of Lagos Mega-city between 2011 and 2013.

Table 4.2: The number of building contraventions and the number of buildings demolished in 16 local governments of Lagos between 2011 and 2013 (Adapted from Wahab & Ojelowo, 2017: 177)

	LGAs in Lagos	Number of buildings		Percentage of buildings demolished of the buildings from contraventions
		**Demolished	*Contraventions	
1	Agege	25	255	9.8
2	Alimosho	46	241	19
3	Lagos Mainland	84	575	14.7
4	Lagos Island	0	131	0
5	Oshodi/Isolo	29	276	10.5
6	Surulere	13	141	9.22
7	Ojo	15	188	8.0
8	Somolu	102	285	35.8
9	Ajeromi/Ifelodun	53	253	20.9
10	Ifako Ijaye	7	163	4.2
11	Ikeja	23	123	18.6
12	Eti-Osa	31	121	25.6
13	Apapa	81	334	24.3
14	Amuwo Odofin	16	207	7.7
15	Mushin	29	141	20.5
16	Kosofe	18	207	8.7
Total		578	3647	15.8

* Data from fieldwork conducted by Wahab and Ojelowo (2017)

**Data from Lagos State Building Control Agency (2013), cited in Wahab and Ojelowo (2017)

The data from Table 4.2 above shows that 578 buildings that were 15.8% of the 3 647 buildings that contravened the planning laws were demolished. It further shows that the Somolu LGA has the greatest percentage (35.8%) of demolished buildings from the number of its building contraventions. Also, the data shows that none of the 131 buildings that contravened the planning

laws in Lagos Island, which is one of the prime urban centres with profound economic activities but with coastal fragility in the city, were demolished.

Examining the number of building contraventions in relation to buildings demolished in a clustered column will enhance the comparative analysis and understanding of the laxity of enforcement of planning laws which is a strategic tool in changing climate mitigation activities in continually growing cities like Lagos Mega-city. The low ratio of buildings demolished to building contraventions might have created and instigated the perception that it is acceptable to contravene the building and planning laws of the city to construct structures in fragile environments such as wetlands and flood plains. This might have contributed to increases in in-migrants and residents constructing buildings in informal settlements and slums in different parts of the city that are predisposed to climate extremes.

Lagos Mega-city has also witnessed the proliferation of slums and informal settlements during its growth and expansion, with some slums attaching to other slums within the city, creating mega-slums (Akanle & Adejare, 2017). The number of slums in the Mega-city is estimated at 100-200, which are mostly located around marshy areas near lagoons within fragile environments, and these areas house about 70% of Lagos Mega-city's population (Adelekan, 2010; Ajibade & Mcbean, 2014; Gbadegesin et al., 2016; Myers & Kent, 2005; Olajide, Agunbiade & Bishi, 2018; Soyombo, 2006; UNDP, 2003). Thus, its urban environmental security is affected and threatened by the increasing numbers of slums, informal settlements and squatters. The informal settlements and slums in the city are typically overcrowded having sometimes insecurity of tenure and most of the time prone to flooding because of deficient drainage systems (Adelekan, 2010; Adelekan & Asiyani, 2015; Birkmann, Agboola, Welle, Ahoje et al., 2016; Cirella & Iyalomhe, 2018). Also, social infrastructure and amenities such as potable water access, health care, energy supply, transportation and physical security are not always readily provided for some of the slums and informal settlements in the city (Bhatta, 2010; Gbadegesin et al., 2016; Hove et al., 2013). For example, Image 4.2 below shows a child fetching water from a shallow well in the Ajegunle area of Lagos.



Image 4.2: A child fetching water from a shallow well in the Ajegunle area of Lagos

Residents of most of the informal settlements and slums are the poor who are pushed by financial constraints to these locations because of the high tenement rate and shortage of affordable or inexpensive accommodation in the developed and comfortable parts of the city (Badmos et al., 2020; Lukeman, Bako, Omole, Nwokoro & Akinbogun, 2014; Stark & Terasawa, 2013). Image 4.3 below shows an informal settlement in Ajegunle in Lagos Mega-city built in a marshy area that is prone to flooding.

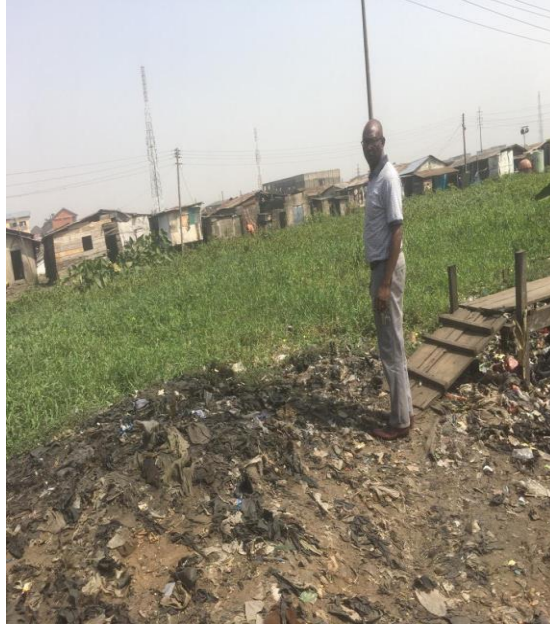


Image 4.3: Informal settlement in Ajegunle of Lagos Mega-city built in a flood-prone area (researcher in the picture)

The informal settlements are sometimes attractive to the poor and the city dwellers because of their unregulated land use, which supports loose economic opportunities for its residents (Adelekan, 2010; Olajide et al., 2018). In a recent study on economic opportunities in the city slums, Badmos et al. (2020) administered 384 questionnaires to household heads in four notable slums in the city (that is, Itire, Iwaya, Ikorodu and Ajegunle). It was revealed that there was a correlation between informal settlements and the informal economy. The study also found that 72% of the surveyed respondents were engaged in unregulated economic activities such as fishing, carpentry, barbing, security, traditional medicine, etc., while 16% were engaged in the formal sector and 12% were unemployed. Figure 4.7 below depicts the employment types in Lagos Mega-city informal settlements.

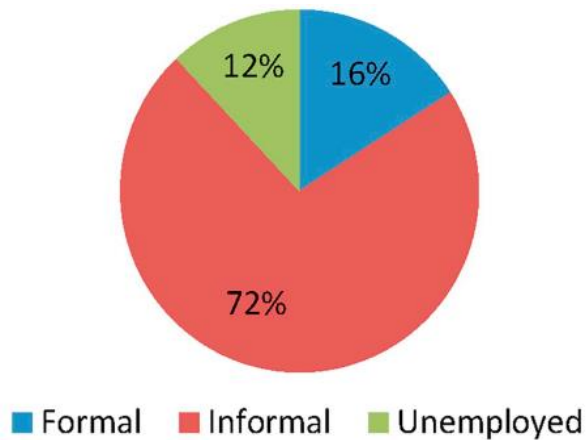


Figure 4.7: Employment type in Lagos informal settlements (Badmos et al., 2020: 7)

It was also found that 63% of the respondents were engaged in informal economic activities within their slums, while 37% were outside the slums (Badmos et al., 2020). Previous studies on poverty and economic activities of dwellers and informal settlements in Nigeria have suggested that economic activities and poverty may be crucial factors that pull city dwellers to informal settlements (Adelekan, 2009, 2010, 2016; Aderogba & Komolafe, 2016; Akanle & Adejare, 2017; Badmos et al., 2020; Ilesanmi & Mgbemena, 2015; Lukeman, Bako, Omole & Akinbogun, 2014). City poverty may denote the levels of the economic well-being of its residents. Hence, the level of city poverty could be determined by the residents' access to urban social amenities such as health and socio-economic infrastructure, which govern the degree of resilience of the people to changing climate. Thus, there may be a strong connection between residents of informal settlements and their poverty levels.

Nigeria is a rich nation but with a high level of poverty within its populace (Ajakaiye, Jerome, Olaniyan, Mahrt & Alaba, 2016; Boyi, 2019). The official estimate of the levels of poverty in Nigeria between 2009 and 2010 was 53.4% based on the poverty line of \$1.90 per person per day in 2011 but has reduced to 48.5% or 90 million people by 2016 and is expected to increase moderately from the year 2017 (World Bank Group, 2018). Currently, the national poverty line for Nigeria is \$1.93 per person per day (World Bank Group, 2022). A recent study tagged the Nigerian Living Standard Survey (NLSS) conducted by the NBS of the FRN in 2019 classified 4 out of 10 Nigerians (about 82.9 million people) as poor and having real capital expenditure below

US\$400 (137 430 Naira) per person per annum (NBS, 2020). The definition of poverty is conflicting and complex, with disagreement in methodologies, framings and measurements (Olsson et al., 2014). Also, poverty is multidimensional, having social, economic and environmental features that need consideration (Cobbinah et al., 2015). The multidimensional poverty index (MPI) approach to measure poverty allows it to be measured as deprivation in three key dimensions: health, education and living standards (Simiyu, Cairncross, & Swilling, 2019). The MPI estimate for Nigeria in 2016/ 2017 was 51.4% of its population and 16.8% was classified as vulnerable to MPI while 56% was in the breadth of deprivation intensity of the population in MPI (UNDP, 2019). Informal settlements, which are slum communities, have always been a place of abode for citizens that reside in the margin of extreme poverty alongside infrastructural decay in mostly cities in third-world countries such as Lagos Mega-city, (Aliu, Akoteyon & Soladoye, 2021; Hallegatte et al., 2016).

The severity of the poverty that ravages Lagos Mega-city is overwhelming. For instance, in a survey conducted by the Lagos State Government on the Lagos Mega-city in 2016 using the purchasing power parity (PPP) of \$1.90 per day of the World Bank for the year 2015, it was revealed that over 80% of the sampled households could not adequately feed themselves and their families due to monetary issues (LBS, 2016). The study further showed that 86% of the household heads were poor. Poverty is an essential feature in explaining the degrees of vulnerability to urban security threats and safety (UN-Habitat, 2007). The impacts of changing climate and its variability are expected to be more severe when it is felt with other stresses such as poverty (Ahmad et al., 2006; Islam & Winkel, 2017; The World Bank, Asian Development Bank [ADB], OECD & DFID, 2012). Therefore, climate variability and change impacts may manifest untold hardship in informal settlements and slum residents in cities mostly because of their poverty levels and the negative socio-environmental conditions of their locations. Invariably the poor in the urban systems may be affected heavily by the effects of climate variability and change, when compared to the remaining population that may experience limited impacts since poverty makes them receive less post-shock support from the financial system, social nets, family and friends (Hallegatte & Rozenberg, 2017; Mehrotra et al., 2011). Thus, climate variability and change are expected to aggravate urban pressures on rapid population growth in Lagos Mega-city, especially in its informal settlements, slums and sprawls (Hallegatte et al., 2016; Rosenzweig, Solecki, Hammer, & Mehrotra, 2010).

4.3.5 Changing climate, Lagos, and the right to the city

The model of urbanisation in some growing cities in the global south, such as Lagos Mega-city, puts economic growth and development over human well-being, undermining the right of all the citizens to the city (United Nations, 2016a). The policy measures that are expressed to regulate urbanisation often extend inequity and push the urban poor to live in risky and vulnerable conditions in fragile environments that lack or have inadequate access to public services and amenities (Lawanson, 2016). Achieving equity and justice has become a mirage in most of these continuously growing cities, including Lagos Mega-city. Also, informality (that is, in the case of housing and enterprises) that are fast becoming the urban reality in many cities in developing contexts compels the urban poor to always contravene the laws in their quest for survival and livelihoods (Lawanson, 2016). This makes them to be at the mercy of the enforcers and the state government, who sometimes have to evict them from their place of abode and livelihoods.

In a bid to transform Lagos Mega-city into a world-class city in recent years, diverse slum upgrade programmes have been initiated, which at most times results in city planners realising that these informal settlements are located in prime locations, which sometimes leads to seizure and control of the slum lands to sell to private entities and elites (Adama, 2020). Thus, the upgrades habitually turn to the eviction of the residents with no consideration for their properties and livelihoods, undermining their right to the city.

In line with urban sustainability and climate security, the adaptation option of retreat is a cogent aspect in coastal cities such as Lagos Mega-city, which are experiencing changing climate impacts. The policy of retreating from natural hazards is a radical adaptation approach that encourages the movement of communities and their assets from places that are most likely to be impacted by changes in climate to less vulnerable places (Sinay & Carter, 2020). This is a plan formulated to preserve communities from the impending hazardous implications of changing climate. Also, there is intra-urban mobility, suburbanisation, long-distance migration, and immobility in cities (Mägi, Leetmaa, Tammaru, & van Ham, 2015). Notably, in-city residential mobility and migrations are inadvertently linked to contemporary demographic and social challenges, which include political, economic, and environmental issues (Coulter, van Ham & Findlay, 2015). There has been increasing spatial mobility and migrations within cities in developing nations, especially at present

than in the past years, because of changes in the nature of work due to industrialisation, rising commercialisation, and increased diversity in people's life courses (Kulu et al., 2018). However, in Lagos Mega-city, the retreat policy for changing climate is commonly affecting the urban poor and the deprived communities that are forcibly evicted in the city's waterfront areas from their place of abode and livelihoods, and most of the time are tactically replaced with a new urban developmental project (Ajibade, 2019). The right to the city and survival of the deprived communities are often not considered on the pretence of changing climate. Some of the evictions, for example, were done without adequate notice, consultations, compensation or provision of alternatives (Amnesty International, 2017). Thus, there is an injustice when the impacts of the retreat policy for changing climate, which disproportionately affects only a particular stratum of society (Ajibade, 2019). Evictions of residents for protection from environmental risks have become a recurring issue in Lagos Meg-city. One of the most recent evictions was carried out on 17 March 2017 at Otedo-Gbame and Itedo (fishing communities) on the waterfront, where about 35 000 residents were displaced by the Lagos State government based on environmental risks (changing climate) and security (British Broadcasting Corporation [BBC] News, 2017; The Guardian, 2017). Another eviction was carried out in Ilubirin communities which is a neighbouring area to Otedo-Gbame between 2-19 March 2017 (Amnesty International, 2017).

The recent urban developmental plans of Lagos Mega-city depict that the changing climate retreat policy of the Lagos State government for the city may be shrouded in its socio-economic development plans though presumed on preventing changing climate impacts on its people. For example, the Eko Atlantic City development programme called the Lagos Mega-city project, with a key purpose of arresting the sea encroachment that is due to changing climate after the eviction, is expected to house about 250 000 people (supposed super-rich) in replacement of the urban poor displaced from the waterfront (Adedeji, 2021; Ekoh & Teron, 2023; The Guardian, 2014). Thus, inequalities are being supported based on the negative impacts of changing climate, which may reserve the right to the city for the very few in this age of climate variability and change. Adedeji (2021) describes the Eko Atlantic project as an unjust city having the epitome of extreme class distinctions with the intent of segregating the elites from the general populace. Therefore, this study intends to focus on considerations that will enable Lagos Mega-city and its surrounding environments to be ecologically and sustainably secure for both people and their surroundings, encouraging equity among the residents in the present and the future in the vein of the unavoidable

impacts that could be generated by changing climate and climate variability. Consequently, to attain the Lagos Mega-city sustainable society integrity will require attention to its urban environmental security, as advocated by Yang, Jia and Wang (2021).

4.4 RESEARCH DESIGN

A research design is a process identified, adopted, employed and followed by a researcher for a study (Creswell & Poth, 2017). The research design depicts the study procedures and approaches. This research adopted the case study tradition in examining the implications of climate variability and change on urban environmental security in Lagos Mega-city in Nigeria. A case study involves the exploration of an issue through one or more settings within a bounded structure (Creswell & Poth, 2017; Tomaszewski, Zarestky & Gonzalez, 2020). Hence, it allows for in-depth analysis within a specific context (Mills, Harrison, Franklin & Birks, 2017).

To achieve the aim of the study, a mixed methods research design was employed in its examination procedure. Mixed methods entail using different methods within a research paradigm. Dawadi, Shrestha and Gir (2021: 25) assert that a research paradigm “refers to researchers' underlying philosophical views concerning the truth and reality in general and the research issue in particular”, and that mixed methods is a complementary research method to the traditional quantitative and qualitative research approaches to permit complex issues to be better understood. They further indicate that mixing two methods might be better than a single method as it can provide trends and rich insights into the research issue being examined, which is unlikely to be fully understood by using only qualitative or quantitative methods. Taherdoost (2022) indicates that the combination of methods depends on the purpose of the study and the nature of the research questions. Given the range of considerations discussed earlier as well as the multiple theoretical and conceptual frameworks that guide the research, it is evident that examining urban environmental security in Lagos Mega-city warrants the use of a mixed methods approach.

The mixed methods included both qualitative and quantitative techniques. This encompasses both exploratory and descriptive studies. The exploratory approach was chosen since there are few studies on urban environmental security alongside climate change (Akhtar, 2016) in locality-

specific contexts. The exploratory approach helps to identify techniques that examine different factors that will relate to each other casually and offers new approaches and angles to explain issues (Reiter, 2017). Thus, it helps to achieve a unique understanding of the issues associated with climate variability and change in relation to urban environmental security in Lagos Mega-city. Since changing climate is a current and existing phenomenon, the study also engages a descriptive approach so that the data gathered was subjected to description and onward interpretation as outlined by Atmowardoyo (2018) and Salaria (2012). Figure 4.8 below displays in graphical form the research design adopted in the study from the identification of the case for the investigation and the utilisation of a mixed methods research design that has qualitative and quantitative parameters as the research procedure through exploratory and descriptive surveys.

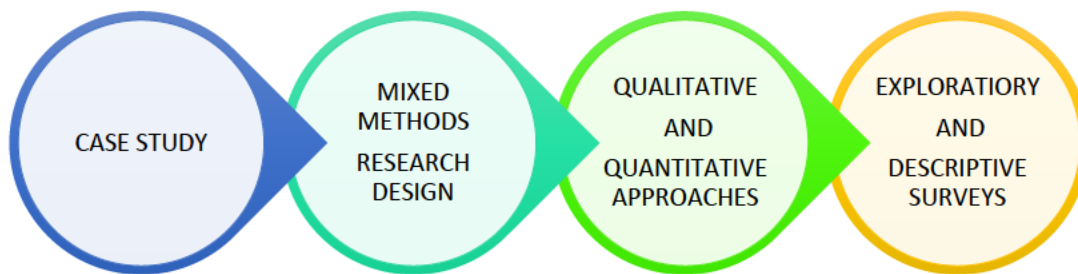


Figure 4.8: Research design for the study

4.5 DATA COLLECTION PROCEDURES

The research activities began by designing the research instruments. The study's targeted population included adult respondents from 400 households from three coastal communities in the city for the structured surveys, six key informants with the staff of the Lagos State Government, and three focus group discussions comprising purposively chosen fishmongers and community leaders. To enable the student to engage in data collection, ethical approval was sought for the protocol from the University of KwaZulu-Natal's Humanities and Social Sciences Research Ethics Committee (HSSREC) on 17th September 2019 and full approval was granted on 28th November 2019 (Appendix 1). Hence, the data collection began in January 2020 till August 2020 and was subjected to both quantitative and qualitative analysis.

4.5.1 Research Ethics

Ethics principles and norms were engaged in the study. Thus, informed consent was sought and obtained from every participant prior to their participation. Specifically, the consent of the respondents was sought for the household questionnaire before their participation. Also, all the key informants and participants of the focus group discussions appended their signatories to an informed consent form given to them prior to their participation in the study.

4.5.2 Document Review

Identifying the extent and nature of climate variability and change impacts in the city involves the study obtaining data on rainfall, temperature, sea level, coastal erosion and flooding from the appropriate departments in Lagos Mega-city (that is, rainfall and temperature from the meteorological stations, changes in sea level and intensity of coastal erosion from the Oceanography Department and flooding from the Ministry of Environment). This information complements recent and up-to-date data from secondary sources such as reports, journals, books and internet resources on climate variability and change impacts on urban environmental security as integrated into the previous chapters.

4.5.3 Sampling techniques

Sampling is a procedure used to scientifically select a smaller number of individuals representative from a population to serve as a data source for experimentation according to the objectives of the study (Sharma, 2017). Sampling is indispensable in this research since it is impossible to gather information from the entire population of the Mega-city because of time and cost considerations. Therefore, a representative part (subset) of the population was selected for the entire study.

The analysis of stakeholders is indispensable in the research since it is a potent instrument that delivers insightful and relevant information connected to the vulnerability context of local communities and institutions (UNDP, 2013a). Therefore, the study engaged both random and purposive sampling to gather the necessary information from the households and key informants, respectively. Random sampling is a selection through probabilistic rules that give each individual an equal chance of being selected (Ilovab & Doroftei, 2019). Purposive sampling is a technique of selecting and identifying individuals or groups that are knowledgeable or experienced about a research phenomenon to get rich and up-to-date information (Palinkas et al., 2015). Each of the data collection tools used in this study is discussed next, together with the sampling approach used.

4.5.4 Structured questionnaire

A questionnaire is a quantitative technique used to gather data from a study through the identification of the complexity of normal life that shapes human experiences, providing insights into social processes, trends, attitudes, values, and interpretations (Mcguirk & Neill, 2016). Therefore, it aids in gathering geographic, demographic and socio-economic data (Ilovab & Doroftei, 2019). Rathi and Ronald (2022) advocate that a questionnaire must be pre-tested to validate its precision and timeliness. The mode of administration and data collection techniques chosen for a questionnaire depend on the characteristics of the target population, topic sensitivity and availability of resources (Mutepfa & Tapera, 2018). However, a self-administered questionnaire has the advantage of gathering data about a large group of people of interest in a short time with ease and with respect to an individual's rate of response (Pozzo, Borgobello & Pirella, 2019).

Information on the nature of climate variability and change impacts on urban environmental security in Lagos Mega-city in Nigeria was gathered from the households using a structured questionnaire with closed and open-ended questions. The open-ended questions were used for easy understanding of the concept by the respondents, while the close-ended questions were used to offer opportunities for considered and structured responses (Ilovab & Doroftei, 2019; Mcguirk & Neill, 2016). As mentioned earlier in the study, 400 copies of the household questionnaire (Appendix 2) were administered to adult household members in the study. Image 4.4 shows a face-to-face interview being conducted through the administration of a structured questionnaire to a household head in the Ajegunle area of Lagos Mega-city during data collection.



Image 4.4: Face-to-face interview through the administration of a structured questionnaire to a household head in Ajegunle, Lagos Mega-city

Household adult representatives (18 years old and over to comply with ethical requirements) were chosen from three selected communities along the coastline of the Mega-city. The coastline communities were chosen because previous studies suggest that low-lying communities on the coast are expected to have costly impacts of changing climate because of sea-level rise and other

disruptions to livelihoods associated with climate variability and change, which could affect human socio-ecological and economic attributes (Adewale et al., 2017; Jaramillo & Nazemi, 2017). These three communities were purposively chosen for the study based on their documented household income levels in the literature. They are Ajegunle in Ajeromi-Ifelodun LGA (low income), Makoko in Lagos mainland LGA (low income), and Bariga in Somolu LGA (low/ middle income) (Birkmann et al., 2016).

The sample size for the study area was selected using the Slovin formula based on the most recent estimated total number of households in Lagos Mega-city. Using the Slovin formula, the sample size was calculated as 400 at a 95% confidence level. The random sampling approach necessitated that each household within the identified communities has an equal chance of being chosen, which limits bias and increases the research validity and reliability. Therefore, random point sampling was used to select the 400 households from spatial maps through the GIS tool, Geospatial Modelling Environment (GME), in the selected three communities. The GME is a suite of spatial analysis tools utilised alongside ArcGIS 10.0 and 10.1. There were no inclusion criteria since the 'point' was the reference to select the household nearest to it. Thus, 400 households were interviewed face-to-face using a household questionnaire (Appendix 2) in the three selected areas. For the household survey, the home at the point or the closest to the point on the geospatial maps was selected, and an adult household member (18 years old and over of age) was interviewed using the household questionnaire. When a chosen household refused to participate or when an adult member was not available, the next home close to the selected location was allowed to participate. Figures 4.9, 4.10 and 4.11 below show the sampling points selected through the GIS tool GME in Ajegunle in Ajeromi-Ifelodun LGA, Bariga in Somolu LGA and Makoko in Lagos Mainland LGA, respectively.

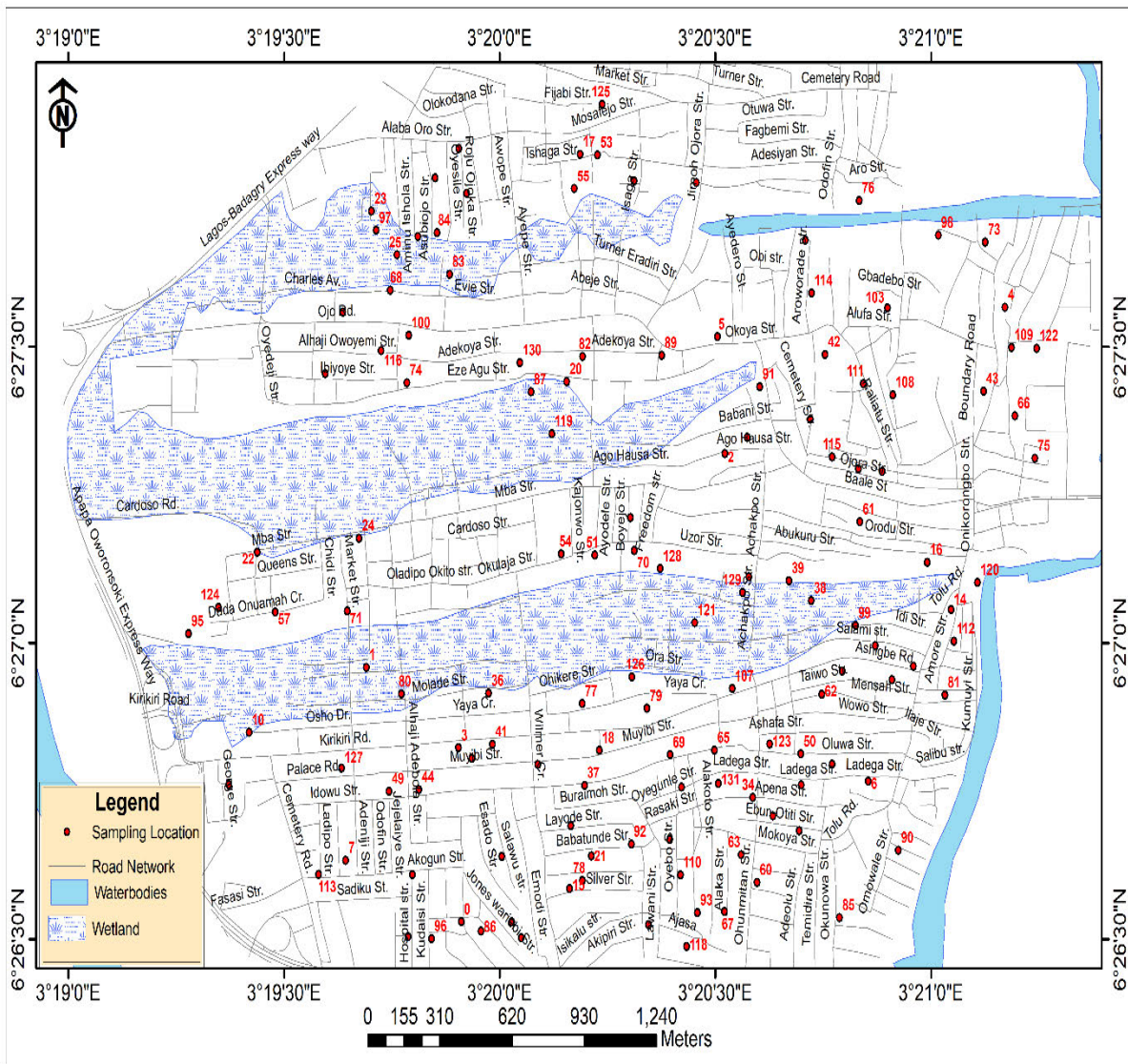


Figure 4.9: Sampling points in Ajegunle in Ajeromi-Ifelodun LGA of Lagos Mega-city showing the

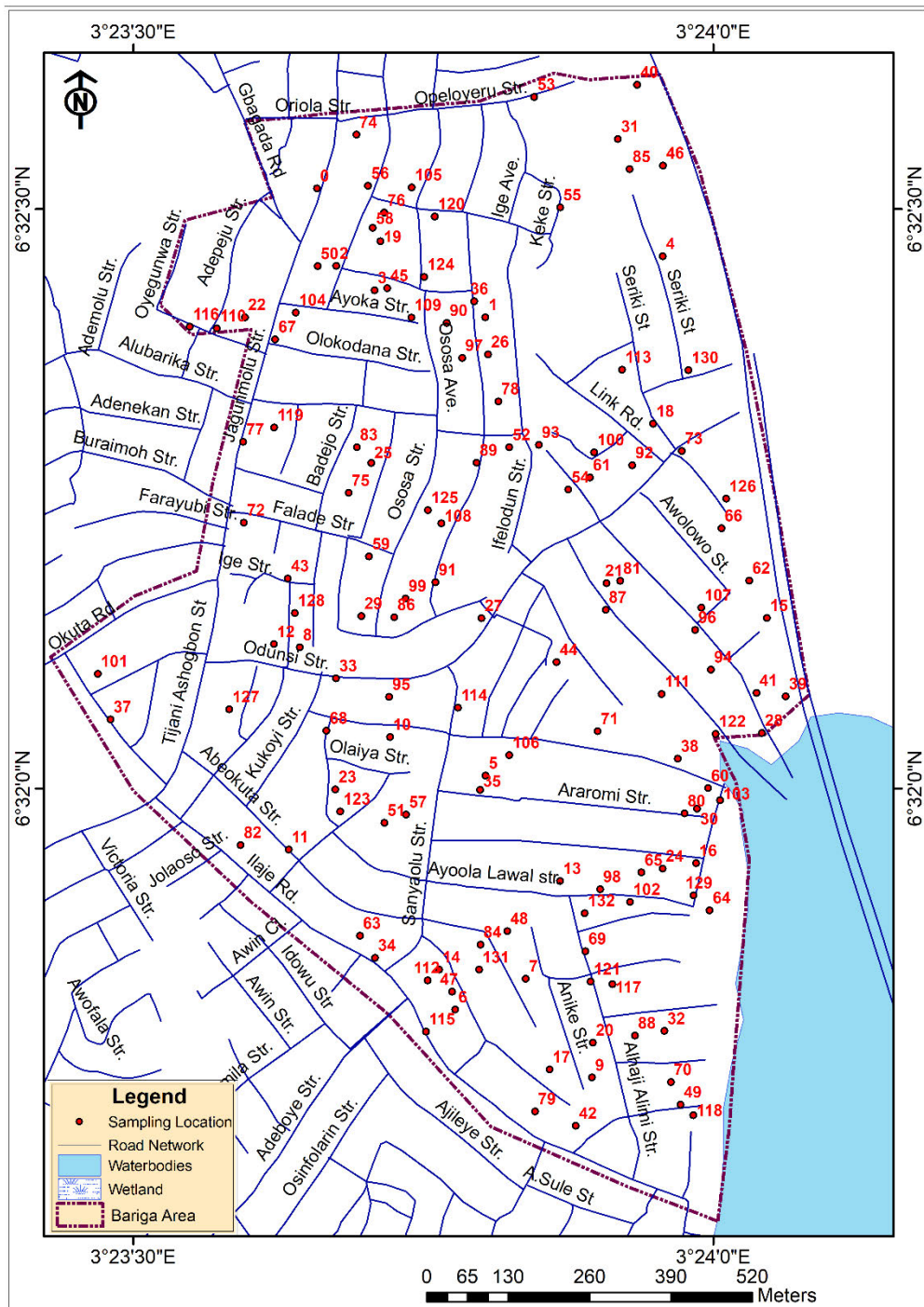


Figure 4.10: Sampling points in Bariga in Somolu LGA of Lagos Mega-city

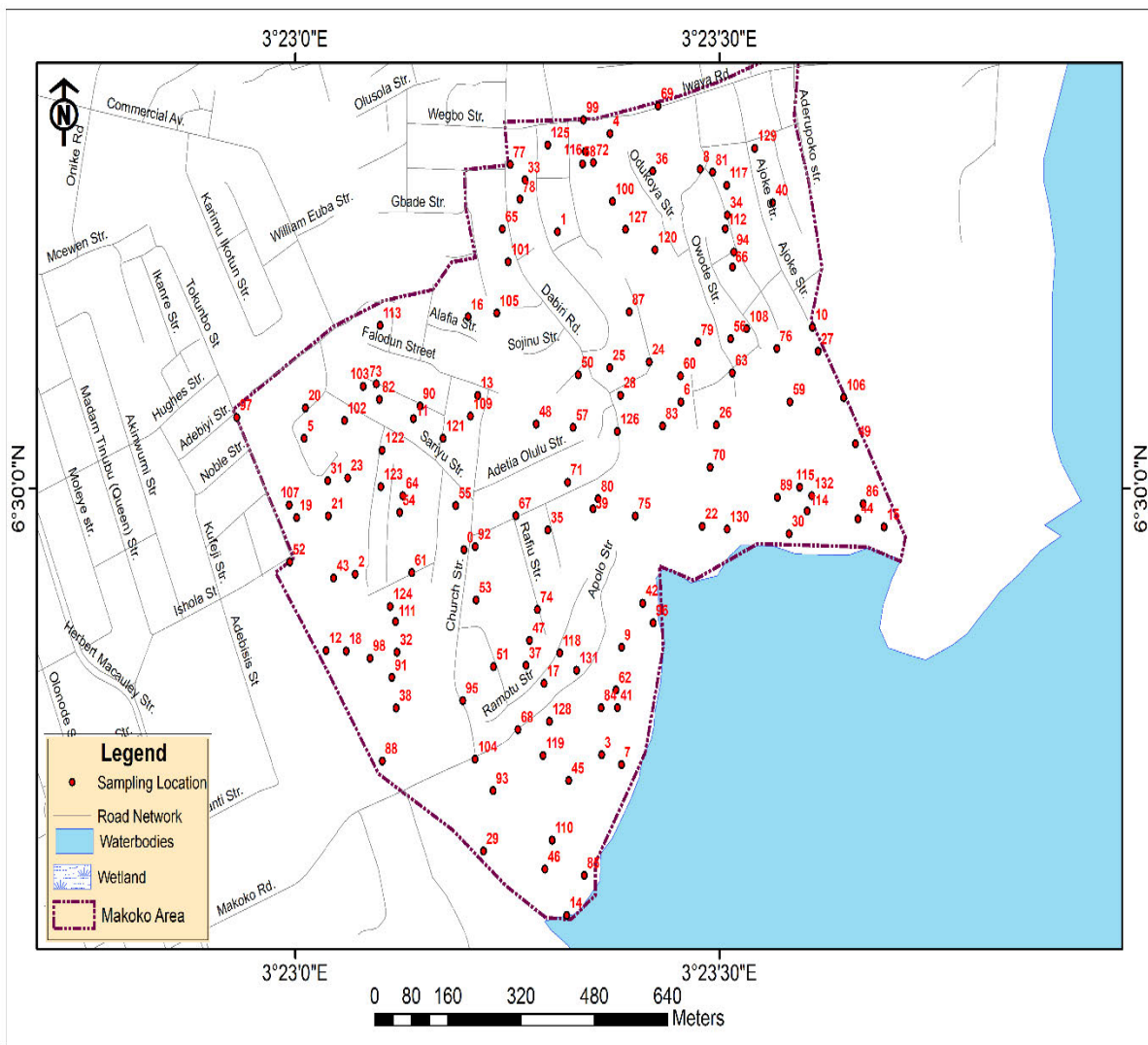


Figure 4.11: Sampling points in Makoko in Lagos Mainland LGA of Lagos Mega-city

4.5.5 Focus Group Discussion

Sim and Waterfield (2019) describe a focus group discussion from the research of Stewart (2018: 687) as “a type of group discussion about a topic under the guidance of a trained group moderator”. Hence, a focus group discussion is similar to interviews, such as a group interview, in order to uncover people’s values, experiences and perceptions (Moon et al., 2019; Nyumba, Wilson, Derrick & Mukherjee, 2018). Therefore, it is used to generate data on collective opinions (Gill,

Stewart, Treasure & Chadwick, 2008; Nyumba, Wilson, Derrick & Mukherjee, 2018). However, the skills of the researcher or the moderator are essential to achieve the objectives of the focus group discussion in encouraging full participation of the participants of the group (Sim & Waterfield, 2019). A focus group discussion is a non-structured interview with a group of people (between 6 to 12) that interrelate with themselves, using their group dynamics to inspire discussions that engender ideas to follow the topics to greater depth (Guest, Namey, Taylor, Eley & Mckenna, 2017; Ilovab & Doroftei, 2019). The group expected target (6 to 12) conforms with the analysis and insight into focus group discussion research conducted by Nyumba et al. (2018) using data from two decades of application in conservation in Africa, Asia and Europe where the target of focus groups were 3 to 21 with a median of 10 persons.

Focus group discussion is a qualitative social scientific research technique that is cost-effective, collecting data that is not numerical in nature from a purposively selected set of persons rather than a statistical representation of an enlarged sample. Apart from the skills of the researcher or moderator that is indispensable in focus group discussions, the identification of the needed participants is crucial in the process since it's the group synergistic and dynamics relationship that enhances the generation of quality data (Nyumba et al., 2018). Hence, the focus group discussion techniques encourage the building of relationships and interactions between the participants and the researcher (Ngizwana, 2018). Sim and Waterfield (2019), in their study on focus group methodology and some ethical challenges, highlight that anonymity and confidentiality may be a challenge since the researcher may not be able to control the communication of the participants outside the group about the study.

The focus group discussions were conducted with purposively chosen fishmongers and leaders using prepared focus group discussion questions (Appendix 3) to guide the discussions in each of the three selected coastal communities to determine their opinions and experiences about changes in aquatic livestock and their livelihoods in respect to the impacts of climate variability and change.

Community leaders were chosen for the focus group discussions because they were expected to be knowledgeable about issues of changing climate and its variabilities in their communities, while the fishmongers were chosen because of literature assertions of the implications of changing climate and its variability on their livelihoods (Fakoya, Oloko & Harper, 2022; Omitoyin & Tosan,

2012; Roa, 2022). The focus group discussions were carried out in Ajegunle (9 participants: 7 males and 2 females), Makoko (9 participants: 5 males and 4 females) and Bariga (10 participants: 5 males and 5 females). The participants in the three focus groups included community leaders, fish mongers, boat transporters and traders. Image 4.5 shows the focus group discussion being conducted with fishmongers and leaders in Ajegule in Lagos Mega-city.



Image 4.5: Focus group discussion involving the fishmongers and leaders in Ajegule in Lagos Mega-city

4.5.6 Key Informant Interviews

Key informant interviews elicit opinions or information from key people who are expected to be knowledgeable or have some ideas about the issue of study (Young et al., 2018). Hence, key informant interviews focus directly on the most knowledgeable experts or professionals who are concerned about the issue being studied and are queried about their perspectives and experiences concerning the matter (Kroloff, Heinen, Braddock, Rehage & Santos, 2019). Thus, key informants to be interviewed for a study are expected to be purposively chosen to stimulate rich data (Palinkas et al., 2015). Thus, they are expected to provide indispensable knowledge that is far more than the contribution of interviewing an ordinary person, which serves as a supplement to data collected from other research techniques (such as focus group discussions and structured questionnaires)

used in a study (Lokot, 2021). Key informant interviews are essential in the analysis of local institutions and their respective capacities (UNDP, 2013a), which is an important activity that was considered during this study. Therefore, the information on issues of policy thrust by the three-tier governments on climate variability and change impacts, adaptation and mitigation were collected from purposively chosen key informants through face-to-face interviews using prepared key informant interview questions which are open-ended questions to allow flexibility in eliciting information from the respondents (Appendix 3).

Six key informants were purposively chosen for this study. They included three senior and middle-level staff from the Lagos State Ministry of Environment, Climate Change Department whose role is to coordinate changing climate actions that enhance adaptation and mitigation of its impacts in the city and three Environmental and Health Officers at the LGAs of the selected three coastline communities that are expected to directly monitor the environment in their domain. The information retrieved from these key informants was complemented by examining and analysing government policy documents on climate variability and change issues.

4.6 DATA ANALYSIS

The contributions of every study materialise through the engagement of chosen dependable and reliable systematic data analysis techniques. This is because data analysis enables researchers to gain a broader knowledge of the issue or problems that are being investigated (Gibson, 2017). Data analysis aids the researcher in recognising and explaining the social phenomena that are being studied (Zulfadilla & Caniago, 2021). It is expected to address the basic research objectives and questions that are highlighted in the problem statement (Sileyew, 2019). Therefore, a veritable data analysis technique is expected to enhance the interpretation of data so that it could address the research challenge and produce results with inspiring conclusions, suggestions and recommendations (Mondal, 2018). Hence, multiple data analytical methods are encouraged in research studies (especially when multiple methods are used, as in the case of this study) since they are mutually informative, providing a comprehensive and synergistic understanding of the investigation being carried out (Harrison et al., 2017). This study engaged both qualitative and quantitative research methodologies. The qualitative data include focus group discussions and key

informant interviews. The data from the quantitative approach, which was the administered questionnaire, were analysed using the Statistical Package for Social Sciences (SPSS), while data from the focus group discussions and key informant interviews, with open-ended questions that were qualitative in nature, were subjected to content quote analysis in line with the research questions and research objectives. The discussion of the quantitative and qualitative results was integrated thematically. Hence, the interpretation of this data was aligned by linking it to the research questions and research objectives of the study

4.7 STUDY LIMITATIONS

The study intended to obtain current climatic data from appropriate departments in Lagos Mega-city. However, some of the important data and information were not available. For instance, the Nigerian Oceanography Department which is supposed to have the current data on the sea level rise, explained that they have not been collecting data for some years now. This, the department claimed, was due to the equipment being non-functional. Other departments, such as the Ministry of Environment which has a Climate Change Department as a Unit, had no climatic data or records for the city except their yearly conference papers. Thus, the departments, the Mega-city and the entire Lagos State depend on researchers' and conference participants' data or information on their changing climate issues. Also, the city Meteorological Department (Weather Station), an agency of the Federal Government of Nigeria (Nigerian Meteorological Agency), has no readily available current climatic data. Therefore, the study utilised available data from the literature and online resources alongside the conducted survey in the city for its analysis. However, generalisations were drawn from the three purposively selected communities chosen for the administration of the household questionnaires based on the documented household income levels from Birkmann et al.'s (2016) study on the city, as mentioned earlier in this chapter. However, to ensure increased reliability of the data, random sampling was used to identify the specific households interviewed using the household questionnaire. Moreover, triangulation permitted accessing and examining information from different sources, including secondary information from literature, reports and academic publications, household questionnaires as well as focus group discussions and key informant interviews.

4.8 CONCLUSION

This chapter examined the strategies and approaches used in gathering, analysing and processing data. The study is a case study that permits understanding and exploring issues through examining micro-level and global trends by utilising robust scientific procedures for its assessment. These procedures were based on the research questions that guided the study. The study utilised a mixed methods research design involving both qualitative and quantitative methods to determine the extent and nature of climate variability and change and its implications on diverse environmental components that affect human well-being and livelihoods in Lagos Mega-city. Therefore, the methodology provided an all-inclusive understanding of the phenomenon by undertaking different facets of research problems and triangulating varied sources of data (Gibson, 2017; Merchant et al., 2021).

Documents on the topics were collected and reviewed from various sources and data survey collection instruments were utilised, aligned to the aim and objectives of the study. The data collection instruments used included structured questionnaires/ surveys for household respondents, a key informant interview schedule used as a guide to probe important information and opinions from stakeholders and the focus group discussion schedule utilised to elicit information from community leaders and fishmongers. The results were further analysed using SPSS and thematic content analysis.

CHAPTER FIVE

DATA ANALYSIS, RESULTS AND DISCUSSIONS

5.1 INTRODUCTION

Data analysis, results and discussions are cogent in defining the nature, genuineness and appropriateness of the conclusions that are elucidated in a study. Thus, obtaining good and reliable results in research activities could only be processed through vivid and up-to-date data analysis procedures. This encourages and instigates the discussions that would lead ultimately to recommendations and suitable conclusions of a study. Therefore, success in research activities hinges on the appropriate data analysis techniques chosen for the study. This thesis utilises a mixed approach through the integration of qualitative and quantitative methodologies in the collection of its data, as indicated in the previous chapter. The data analysis is fashioned in thematic forms that were shaped by specific trends and based on the orientation of the study, as outlined in the introductory and previous chapters.

5.2 DEMOGRAPHIC AND SOCIO-ECONOMIC ATTRIBUTES OF THE STUDY AREAS

Demographic and socio-economic attributes are indispensable in the determination of the implications of changing climate and climate variability. This is because these attributes have a significant link to the challenges, mitigation and adaptation to changing climate (Harper, 2019; Matsumoto, 2019; Population Action International [PAI], 2011). Consequently, previous literature reveals that attitudes toward changing climate are usually linked to demographic and socio-economic parameters such as age, gender, marital status, culture, education and household income levels (Anum, Ankrah & Anaglo, 2022; Feinstein & Mach, 2019; Owusu et al., 2018; Sun & Han, 2018). Therefore, demographic and socio-economic dynamics are important keys in identifying responses to changing climate and are essential in the formulation of adaptation strategies (George & Daniel, 2013; Lutz & Striessnig, 2015).

Previous research shows that the implications of changing climate and its variations are distributed differently across diverse strata, including gender considerations (Owusu et al., 2018; Pelling et al., 2022; Reckien et al., 2017). However, the gender distribution of this study was not predetermined since the target of the research was to conduct an interview and retrieve household and community-level information in relation to urban environmental security and changing climate without prejudice from an adult household member. Figure 5.1 below represents the gender distribution of the respondents who participated in the study.

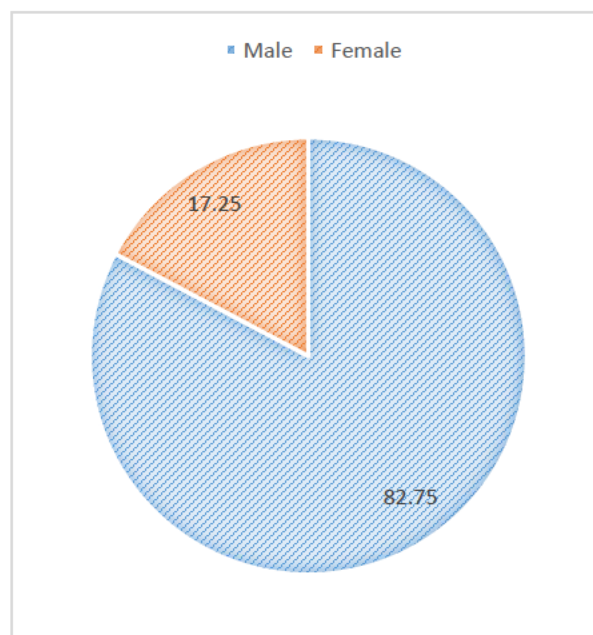


Figure 5.1: Gender distributions of the household members engaged in the study (n=400, in %)

As indicated earlier, the households were randomly selected with the expectation that an adult representative would participate. It was found that about three-quarters of the respondents were males. This may be due to the predominant patriarchal norms and family systems that are already embedded in Lagos Mega-city's societal culture of the residents, which favours males over females' participation in external activities (Adisa, Abdulraheem & Isiaka, 2019; Olatunji & Glory, 2021). It was also found that 82.75% of the respondents were household heads, while the

remaining 17.25% were not. This may be because the household head in Lagos and Nigeria is often the primary provider of the expected economic needs of the members of the household, which are most times socially and culturally attached to the male than the female gender, who is expected to provide direction for members of the household (Bamgboye et al., 2020).

The high level of representation of the household heads in this research may be an advantage to the study since household heads are expected to be more knowledgeable about their households than their members (Institute of Statistical, Social and Economic Research, Economic Growth Centre [ISSER/ EGC], 2015). The household head-sex ratio data for the Mega-city from the 2016 report of the survey of the Lagos State Government was 4:1, which means for every female household head, there are approximately four male household heads (Lagos State, 2016). Likewise, the sex ratio data for the respondents in the study is approximately 3:1, which means one female to three males. This is close to that of the Lagos State Government survey of the household heads. However, this study is particularly gender-focused since data were also collated from other sources, including the literature, key informant interviews and focus group discussions, which compensates for the male dominance. Table 5.1 below represents the statistics of the household heads in the study.

Table 5.1: Number of household heads and non-household heads in the study (n=400)

Number category	Frequency	% of respondents
Number of household heads	331	82.75
Number of non-household heads	69	17.25
Total	400	100

The age brackets of the household respondents were analysed (Table 5.2). It was found that the age bracket 31-40 years had the highest proportion at 36%, followed by 41-50 years, which was 29%. This was followed by 51-60 years (14.75%) and 21-30 years (10%). Respondents who were above 60 years was 9.25%, and 1% were 18-20 years. The age of the citizens in society may have a role to play in the determination of its climate security. The literature examined for this study also showed that younger adults are more likely to reflect on news reports on changing climate,

care about the challenges and also have confidence in the occurrence of changing climate (Clayton, 2020; Han & Ahn, 2020; Lee, Gjersoe, Neill & Barnett, 2020). The older generation has the advantage of seeing and experiencing the changes and variations in climate over the years (Span, 2019). In contrast, Goto, Raimi, Wilson and Árvai's (2019) study suggests that age and generation had non-existent and inconsistent effects but gives preference to value and political orientations as a better predictor of environmental action and concern (Goto et al., 2019). Gallup research in the USA shows that 70% of 18 to 34 years old Americans have apprehension about global warming when compared with 52% of the older groups from 35 to 54 years and also 56% of those that are 55 years and older (Reinhart, 2018). In this study, close to half of the respondents were below the age of 40 years.

Table 5.2: Age brackets representation in the study (n=400)

Age categories (in years)	Frequency	% of respondents
18-20	4	1
21-30	40	10
31-40	144	36
41-50	116	29
51-60	59	14.75
Above 6	37	9.25
Total	400	100

The study also determined the marital status of the respondents. This is because marital status is a dynamic social category that constructs social relations in terms of rights and duties, particularly for women (Aelst & Holvoet, 2016). Therefore, it is indispensable in climate impact analysis and environmental security assessment. This is in the vein that changing climate and its variabilities influence social constructs in societies differently (Ojakorotu & Olajide, 2018; Olajide & Lawanson, 2014; Owusu et al., 2018). It was found that 82.25% of the respondents were married, while 9% were single. Additionally, 5.25% of the respondents were widowed and 3.5% were divorced. The marital status of the respondents in the study is represented in Figure 5.2 below.

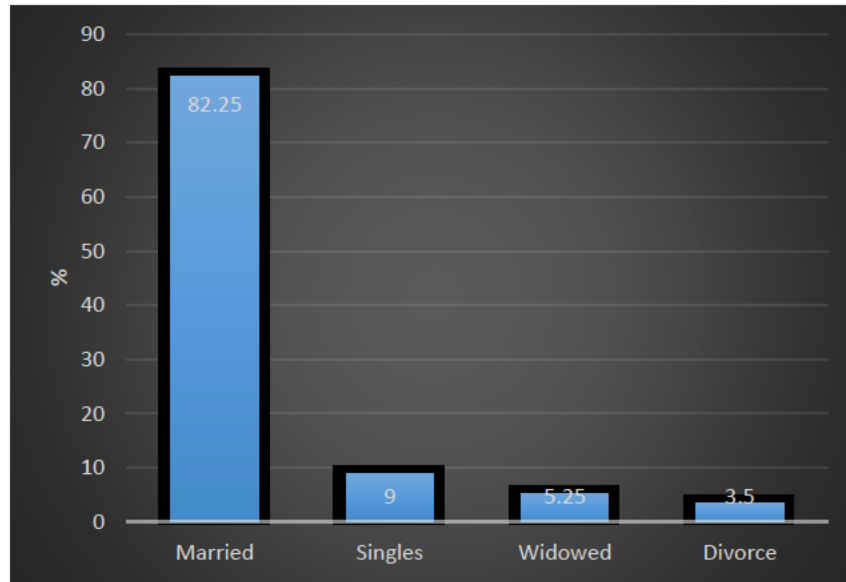


Figure 5.2: Marital status of the respondents in the study (n=400, in %)

Languages are effective instruments that can be used in the communication of information and concepts of changing climate and climate variability as well as to delineate adaptation, amelioration and mitigative approaches in impacted and likely impacted societies. The use of local languages is indispensable for developmental workers, which include NGOs, implementing partners and the government in creating changing climate awareness (UNFCCC, 2016). Nigeria is a multicultural and multilingual society that adopted the English language as its lingua franca. Lagos Mega-city, however, is situated within the enclave of the Yoruba Kingdom where the local spoken language is the Yoruba language. Additionally, the metropolitan nature of the city embraces the multicultural and multilingual nature of the Nigerian federation. The three main spoken languages in Nigeria (Yoruba, Hausa and Ibo) are commonly and culturally spoken by indigenous people of those tribes, mostly in their homes. Other languages spoken in homes include Egun, Ijaw, Ibibio, Fulfulde, Tiv, Edo and Kanuri. Pidgin English is a special language that protruded with diverse modifications in tenses and predicates from the English language and is widely accepted, spoken and patronised by the populace of Lagos Mega-city and Nigeria as a whole (Ojo & Ogunjimi, 2020).

The study evaluated the spoken home language of the respondents. It was found that they were diverse, with the Yoruba language being prominent (53.25% of the respondents spoke the Yoruba language at home). This was followed by 22% of the respondents who identified the Ibo language as their home language. The English language was spoken in 2.25% of the households and the Hausa language was spoken in 1.75% of homes. Furthermore, 17.75% of the respondents spoke other languages in their homes. The spoken home language of the respondents in the study is represented in Figure 5.3 below

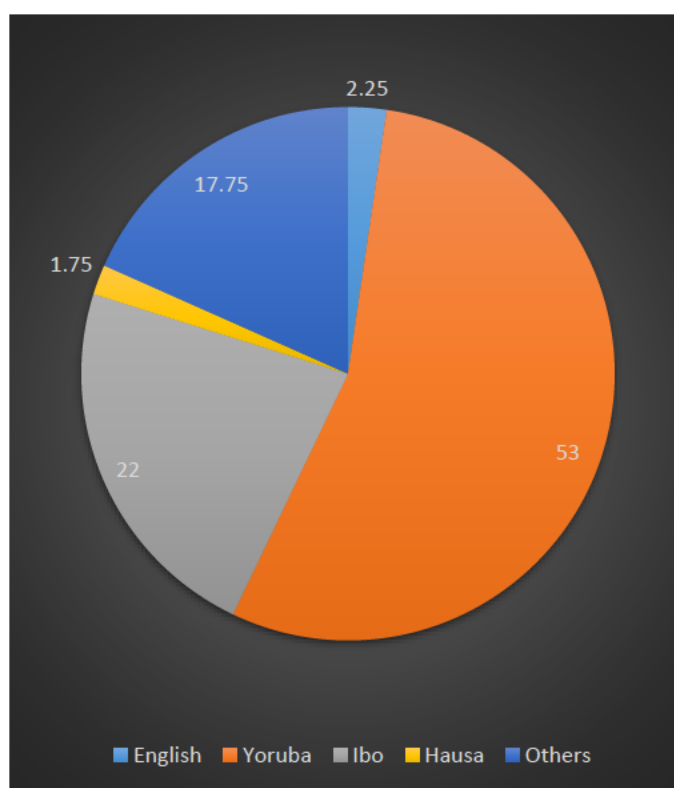


Figure 5.3: The spoken home language of the respondents in the study (n=400, in %)

Education is a veritable key to understanding the process of building resilience and also the development of adaptation strategies by citizens due to its indispensable role in learning which creates changes in knowledge, identity, skills, and socio-cultural roles (Feinstein & Mach, 2019). Thus, formal education relevancy is crucial in the building up of climate security since it supports properties that encourage the shaping of skills that enhances adaptation and mitigations techniques

and the changes in approaches to social systems, which support coping abilities to climate variability and change impacts (Wamsler & Brink, 2012). Formal education (the ability to read and write) is a human capacity that is a skill for a nation's human and socio-economic development (Oluwafemi Olajide, 2013). Hence, significant numbers of climate adaptation literature recognise that the cognitive component of individuals is important in determining their adaptive capacity and is essential in processing climate information, including assessing probable adaptation strategies and assessing risks (Walker et al., 2021). In line with the above, the formal education levels of the respondents in the study were collated. It was revealed that 92.5% of the respondents had formal education, which was from partial to postgraduate levels. This is in line with the records from the household survey of the Lagos State Government conducted in 2012 and 2016 that reported 89% and 91% literate levels, respectively (Lagos State, 2016; Olajide, 2013). This shows that with favourable conditions, the majority of adult households in the city have adequate capacity and skills to pursue their livelihood objectives.

Specifically, in this study, 40.75% of the respondents completed their secondary schooling, while 9.5% had partial secondary education. Primary education was completed by 13.25% of the respondents, while 7.5% had partial primary education. Additionally, 9.25% of respondents had post-secondary certificates or diplomas, 11.75% had undergraduate degrees and two (0.5%) had postgraduate degrees. Only one respondent indicated adult-based education (ABED), while 7.5% had no formal education. The levels of formal education attained by the respondents are represented in Figure 5.4 below.

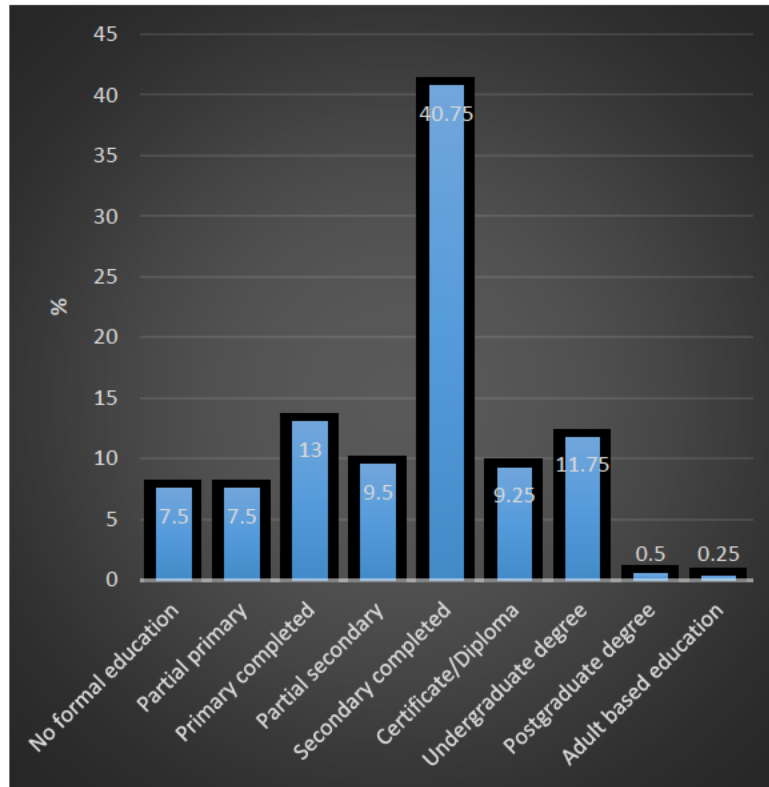


Figure 5.4: Levels of formal education of the respondents (n=400, in %)

The high levels of formal education in the city may be attributed to the government policy of free and compulsory primary education in government-owned schools that has been in existence since the 1950s. This was also consolidated in 1979 with free secondary education in government schools. This policy has been sustained by all the governments of the state. Thus, every city resident has the opportunity of being part of these laudable programmes. Also, more recently, there has been extensive access to primary school in Lagos across gender, location, and socio-economic status with the contributions of private sectors to the creation of about 12 000 primary schools where about 57% of the school population were given opportunities to study (Baum, Abdul-Hamid & Wesley, 2018). In recent research conducted on the determinant of household adaptation to changing climate in Lagos, Okunola and Bako (2021) affirm that residential characteristics, including education, influence the adoption of climate adaptation strategies to the impacts of the changing climate in the city. The growing high levels of education are expected to enhance the

road to climate security in the city and also positively influence the city’s urban environmental security.

The occupation of the respondents was collated in the study. Trading or business were the most prominent occupation indicated by most of the respondents (55.25%), followed by formal employment in the private sector (16.25%). Respondents engaged in fishing as a vocation were 13.5%, and those involved in sales of agricultural products were 1.25%. Those who had formal government employment were 1%. Two respondents stated sand miner and only one respondent indicated remittances. However, 10.75% of the respondents were unemployed. It is important to note that this unemployment value may not take into consideration the rate of informal employment, which includes some business activities that are not formal (Rigon, 2018). The occupation of the respondents is depicted in Table 5.3 below.

Table 5.3: Occupations/ sources of income of the respondents in the study (n=400)

Occupations of respondents	Frequency	% of respondents
Formal employment in the government sector	4	1
Formal employment in the private sector	65	16.25
Sales of agricultural produce	5	1.25
Trading or business	221	55.25
Sand miner	2	0.5
Remittances	1	0.25
Fishing	54	13.5
Pension	5	1.25
Unemployed	43	10.75
Total	400	100

Occupation being a social concept may be impacted by changing climate and climate variability. Challenges created by changing climate could lead to the creation of jobs, the transformation of some existing jobs, and also the destruction of jobs (Diamond & Zhou, 2021; Ogola, 2022; Olsen, 2009). Although difficult to quantify, climate events may directly affect peoples’ occupations which mostly include agriculture, trade, and marketing in developing economy countries (Ahmed, 2015). Information from the participants during the focus group discussions and key informant

interviews supports this assertion. For example, one of the female respondents on issues of occupation in relation to changing climate and climate variability said:

The impacts of changing climate have negative impacts on our economy. Some of the younger generations now lack what to do since fewer fish are caught from the lagoon and there is no more land space in most communities to practice agriculture. Also, paid employment is difficult to get.

Monthly earnings from the work engagements of the respondents were collated in the study. Table 5.4 below depicts the earnings of the respondents in the study in US dollars equivalence per month.

Table 5.4: Earnings of the respondents in US dollars equivalence per month (n=400)

Earnings equivalence per month in US dollars	Frequency	% of respondents
None	42	10.5
< 25	1	0.25
26-50	19	4.75
51-100	119	29.75
101-150	112	28
> 151	107	26.75
Total	400	100

This analysis of the earnings of work engagement or income of the respondents is essential in this study because it is one of the factors that may enhance social inequalities in an urban society, which supports disproportionate suffering from the adverse effects of changing climate and its variations (Campbell, 2022; Fagliano & Roux, 2018; Islam & Winkel, 2017). It was found that 26.8% of household respondents earned above 150 US dollars equivalence per month while 28% earned between 100-150 US dollars equivalence per month. Likewise, 29.8% earned between 51-100 US dollars equivalence per month and 4.8% earned between 26-50 US dollars equivalence per month. Furthermore, one respondent earned less than 25 US dollars equivalence per month, while 10.25% had no earnings per month. From the data derived from the earnings of respondents, it was revealed that 62.75% of the total household respondents earned below 150 US dollars per month, while 10.25% had no monthly earnings.

The total size of each of the households engaged in the research was collated as part of the demographic profile of the study. This is because previous studies have shown a correlation between household size and the implications of changing climate and its variability. Household composition and structure are indispensable in the generation of income for a household (Olajide, 2013). Household income is pivotal in determining the levels of climate adaptation technologies embraced in a home (Islam & Winkel, 2017; Owusu et al., 2018; World Bank, ADP, OECD & DFID, 2012). Also, the impacts of changing climate worsen income inequalities (Cevik & Jalles, 2022). The total household sizes were between 1 and 16 (Table 5.5). The size of the household in the study with the largest proportion was 6 (18.5%), followed by 5 (17.5%) and 7 (16.25%). Also, 12.25% of the households in the survey had a size of 9, while 7.5% of the households had a size of 8 and 6.5% of the households had a size of 4. Furthermore, it was found that 5.25% of the households in the survey had a size of 11, 5% of the households had a size of 10 while 4.25% of the households had a size of 3. Also, 2.5% of the households had a size of 13 while 2.25% of the households had a size of 12 and 0.75% of the households had a size of 14. However, two of the households each had sizes of 1 and 2. Likewise, one household each had sizes of 2 and 16.

Table 5.5: Total household sizes in the study (n=400)

Size of the households	Frequency	% of respondents
1	2	0.5
2	1	0.25
3	17	4.25
4	26	6.5
5	70	17.5
6	74	18.5
7	65	16.25
8	30	7.5
9	49	12.25
10	20	5
11	21	5.25
12	9	2.25
13	10	2.5
14	3	0.75
15	2	0.5
16	1	0.25
Total	400	100

The mean (average) value of the total household size in the study is approximately 7 persons while the mode is 6 persons, which is the total household size with the highest number of respondents in the study. The mean value of the household size is a little higher than the average household size of 6 persons in an investigation on the Lagos Metropolis where Ajegunle, Oko-Baba, Ipaja and Sari-Iganmu were chosen as the study areas and also higher than the 5 persons recorded in the Lagos State Government Household Report of 2012 (Olajide, 2013). The value corresponds to the urban average household size of 8 and 7 persons determined for urban and rural Lagos, respectively, in a 2017 socio-economic study on urban and rural Lagos (Abdulganiyu & Sodiq, 2017). However, the 2016 household survey report of the Lagos State Government estimated the average household size of the mega-city at 5 persons per household with an average of 13 persons per dwelling in a housing unit (Lagos State, 2016).

The study analysed the years in ranges that each of the respondents' families has been residing in Lagos Mega-city. It was found that 81.5% of the households have been residing in Lagos Mega-city for 5 years and above, while 16.75% have resided for 1-5 years in the city. However, only 7 of the respondents (1.75%) lived in Lagos for less than a year. Table 5.6 depicts the year in ranges that the families of the respondents have been residing in Lagos Mega-city.

Table 5.6: Years in a range that the family has been residing in Lagos Mega-city (n=400)

Year(s) residing in Lagos	Number of respondents	% of respondents
Less than a year	7	1.75
1-5 years	67	16.75
5 years above	326	81.5
Total	400	100

The study also analysed the places where the respondents and their families were residing before moving to their present location in Lagos Mega-city. Table 5.7 below depicts the places where the respondents and family were living before residing in their location in Lagos Mega-city.

It was found that 42.5% of the respondents and their families were living in the location without a previous place of abode, while 22.5% were residing in another area of the city before residing in

the present location, and 7.75% were residing in Lagos but outside the Lagos Mega-city. Furthermore, 25% of the respondents lived outside Lagos but within Nigeria, and only 2.25% lived outside Nigeria before relocating to the Mega-city. The respondents gave diverse reasons for leaving their former locations to reside in their present locations in the Lagos Mega-city. The reasons given by the 57.5% of the respondents who moved included increasing business opportunities, employment, family issues, proximity to work, low rent, work transfer and coming to a better location. It is also important to note that the longer people reside in a specific location, the more likely they are to have stronger place attachments, which are important to consider in the context of climate variability and change that influences environmental change (Dandy et al., 2019; Groshong et al., 2020; Walker et al., 2015).

Table 5.7: Place where the respondents and families were living before residing in their location in Lagos Mega-city (n=400)

Places	Frequency	% of respondents
Lived in the location/ not applicable	170	42.5
In another area within Lagos Mega-city	90	22.5
In Lagos but outside Lagos Mega-city	31	7.75
Outside Lagos but in Nigeria	100	25
Outside Nigeria	9	2.25
Total	400	100

The type of residence a household occupies is an important physical asset, whether as ownership, rented or as a squatter (Oluwafemi Olajide, 2013). Thus, the study classified the respondents' residences as personal property (owner of the house/ my house), renting, and others (that is, living with a relative, friends, etc.). It was revealed that 28.5% were the owners of their houses, while 56.25% of the respondents lived in rented apartments (Figure 5.5). The rest of the respondents (15.25% - indicated as others) resided with their relatives.

The majority of the respondents were not the owners of their homes, while a little above a quarter of the respondents resided in the homes they owned. The study's analysis of the respondents' resident classification was similar to the data from the 2016 survey of the Lagos State Government,

which reported that 23% of the residents lived in houses that they owned, while 69% rented apartments, 5% were gifts and 3% were borrowed-free occupants (Lagos State, 2016). Figure 5.5 depicts the types of respondents' residences or places of abode in the study.

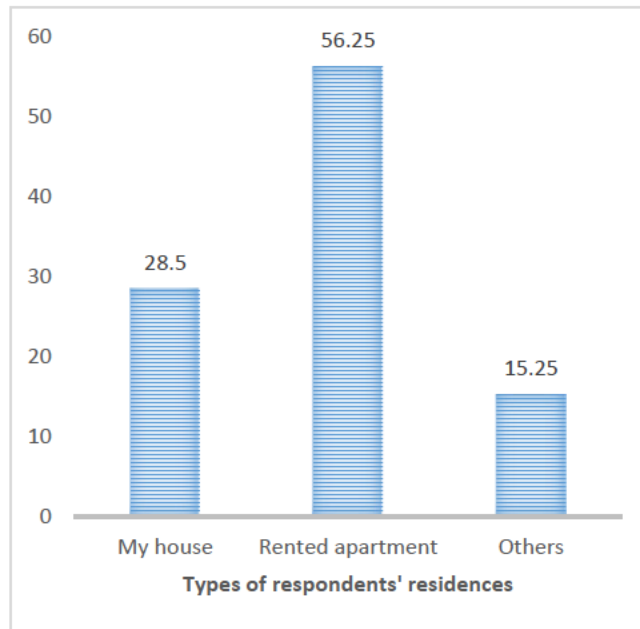


Figure 5.5: The types of respondents' residents or places of abode in the study (n=400, in %)

The Office of the United Nations High Commission for Human Rights (2022) reiterates that those who are homeless or lack secure or resilient homes are expected to be adversely impacted by extreme climate events. Hence, the materials used in the construction of the residences of the respondents in the study were assessed. This is on the premise that the strength of the resilience to changing climate in urban society is a function of the materials used in the construction of the residences of the respondents since structures built outside the formal laws and regulations lack structural integrity and basic facilities that may undermine the ability to cope with the impact of climate variability (Satterthwaite et al., 2020; Williams et al., 2019). The residences in the study area were classified into two categories: formal structures (these are houses constructed with bricks and mortar) and informal structures or shacks structures (these are houses constructed with materials such as roofing sheets, wood or planks, tarpaulins, roofing plates, thatch, etc.). Table 5.8

below represents materials used in the construction of respondents' residences in the study. The results show that 92% of the household respondents' houses were formal structures, while 8% were informal or shack structures. These informal structures were found mainly in the Maroko community of the Mainland LGA and the Ilaje community of Somolu LGA of the Mega-city. These informal structures included the floating houses that were constructed along the canal leading to the lagoon and on the lagoon itself.

Table 5.8: Materials used in the construction of the study respondent residences (n=400)

Materials used in the construction of respondents' residences	Frequency	% of residences
Brick and mortar (formal structure)	368	92
Informal/ shack structure	32	8
Total	400	100

The need to focus on residential housing is highlighted by Ali et al. (2021) and Jayasinghe and Stewart (2022) who assert that although the construction industry globally is one of the highest sources of greenhouse gases responsible for over 50% of the emissions, changing climate and its variability has profound consequences on residential buildings that require appropriate strategies for its management and sustainability. Image 5.1 below is a cluster of informal structures and floating houses along the canals in the Makoko area of the city leading to the Lagos lagoon taken when the survey data collection was undertaken.



Image 5.1: Informal structures and floating homes along the canal leading to Lagos lagoon in Maroko Area of Lagos city

The study analysed the sources of energy used by the households that were interviewed in the study area. It was found that the households were using multiple energy sources. Table 5.9 shows that the main and most common source of energy in the study area was electricity which 89.25% of the respondents acknowledged was used in their households, while paraffin (called kerosine in Lagos) was used in almost all the households (97.25%). Paraffin was mostly used to power cooking stoves and lanterns to provide light during the incessant outages experienced in the city. Only four respondents (1%) used fuelwood as a source of energy for their cooking activities in the study area. Also, candles were always used as a substitute by 58.25% of households, mostly when there was a power outage. Additionally, 23.75% of the respondents affirmed the use of gas for cooking, while only one respondent used solar energy to supplement energy consumption. Thus, the use of renewable energy is almost non-existent, denoting the reliance on traditional sources of energy which is indicative of energy poverty (Day et al., 2016; Siksnyte-Butkiene et al., 2021; Sovacool & Drupady, 2016). Two respondents (0.5%) solely identified power-generating sets, powered by petroleum fuel, as their only energy source since they were not connected to the public power source.

Energy use is indicative of the extent to which households contribute to air pollution (and thereby climate change), as well as the extent of energy poverty experienced, as noted in the literature (Day et al., 2016; Siksnyte-Butkiene et al., 2021; Ogwumike & Ozughalu, 2016; Sovacool & Drupady, 2016), which reflects poverty more generally that denotes the extent to which households are vulnerable to climate variability and change. The use of mixed and traditional energy sources also reveals energy poverty, as highlighted by Day et al. (2016) and Siksnyte-Butkiene et al. (2021).

Table 5.9: Sources of energy currently used by households (multiple responses) (n=400)

Sources of energy currently used by households	Frequency	% of households
Electricity	357	89.25
Fuelwood	4	1
Gas	95	23.75
Paraffin	389	97.25
Candle	233	58.25
Solar	1	0.25
Generator	2	0.5

The importance of water supply and security is highlighted in the literature, noting that water insecurity poses threats to health and livelihoods (Boadi et al., 2005; Lin et al., 2021; Livingston, 2021; Mukwirimba et al., 2022; Sadoff et al., 2017). The main sources of water for drinking and domestic use in the study area were assessed as well. Multiple and diverse sources of water for drinking and domestic use were available and utilised by different households in the city, especially within the context of the inadequate potable or public supply in the city, a concern noted by Boadi et al. (2005) and Lin et al. (2021) for African cities. Therefore, the study accommodated multiple responses in its survey. Table 5.10 below depicts the sources of water for drinking and domestic use in the respondents' households surveyed. The highest proportion of respondents (46.25%) indicated that their households were using dug wells, followed by 38.25% that used sachet water for drinking and 30.25% used boreholes. Furthermore, 24.25% of the households have tap water, while 10.25% have tap water located outside their home and 8.75% from the Maroko fishers' community living in floating homes were connected to the paid pipe. Also, 3% of

the households made use of water vendors as sources of their water which was used mostly for domestic purposes.

Table 5.10: Sources of water for drinking and domestic use (multiple responses) (n=400)

Sources of water for drinking and domestic use	Frequency	% of households
Reticulated tap water in the home	97	24.25
Reticulated tap water outside the home (in the yard)	41	10.25
Boreholes	121	30.25
Wells	185	46.25
Water vendors	12	3
Sachet water	153	38.25
Paid pipe	35	8.75

The reliance on multiple water sources (especially sources that were not tap water within the homes) is also indicative of water insecurity, as noted in the literature (Jaramillo & Nazemi, 2017; Mukwirimba et al., 2022). The responses also resonate with Upton et al.'s (2019) findings that households in Lagos use multiple water sources, including those that are not dependent on those supplied by the city. The (over)use of natural sources has serious implications for the natural resource base (Upton et al., 2019).

One of the male participants during the focus group discussion affirmed the non-availability of potable and domestic water in their locality and linked it to their increased vulnerability, especially in relation to the health implications. He stated:

There is no portable water in this community. Thus, some residents, especially children, fall prey to water-borne diseases such as typhoid fever regularly. Also, affordable government hospitals, unlike private clinics, are far away from us.

Thus, the potable water needs of the city exceed their access and availability but may also require the standardisation of its quality, highlighting the need for improved water management, as noted by Mukwirimba et al. (2022). This is because the lack of a sewerage system and pollution from inadequate management of wastes may lead to pollution of the water resources in the city (Shiru et al., 2019). The challenges in potable water security that is currently witnessed in Lagos Mega-city may be enhanced with the present-day climate variability and change concerns.

The relationship between water and sanitation cannot be overemphasised when considering the health of the public, especially in this age of climate variability and change, as shown by Akinbode et al. (2016), Fantini (2020), Sadoff et al. (2017) and Mukwirimba et al. (2022). Increasing rainfall during the rainy season, which is common to Lagos Mega-city, may further instigate sanitation issues. This is linked to the view that frequent heavy rainfalls, mostly during the rainy season, that leads to recurrent floods could create sanitation issues that sometimes lead to an upsurge in diseases caused by waterborne organisms (Olajide & Lawanson, 2014). Previous studies have provided evidence of a rise in water-related diseases after excessive floods caused by the increasing intensity of rainfall, mostly because the onsite systems are always vulnerable to flooding, which sometimes washes them into water suppliers or discharges the septic systems into the larger environment (Howard, Calow, Macdonald & Bartram, 2016). Lagos Mega-city, at present, has no sewerage systems, leaving every house or property to create or have a soak pit or septic tank to store faeces from the toilets. Thus, it could negatively impact society's public health.

The sources of sanitation were examined in this study. Table 5.11 below depicts the sanitation facilities in the study areas. It was found that about half of the total households surveyed (49.5%) had formal toilets in-dwelling linked to septic tanks, while 15.25% of the households had formal toilets outside the dwelling linked to the septic tank. Thus, the total proportion of households with formal toilets in use was 64.75%. Additionally, 16.5% of the households used pit latrines and 6.75% used communal latrines. It is important to note that 12% had no toilets. Daramola and Olawuni (2017) revealed from their studies that 79.7% of Lagos residents used both flush and ventilated improved pit latrine toilets which could be regarded as adequate (that is, formal toilets in-dwelling and outside-dwelling linked to septic tank). Hence, this result is similar to the findings of this study.

Table 5.11: Type of sanitation facilities in the respondents' households (n=400)

Type sanitation facilities in the respondents' households	Frequency	% of households
None	48	12
Formal toilet in-dwelling linked to septic tank	198	49.5
Formal toilet outside dwelling linked to septic tank	61	15.25
Pit latrines	66	16.5
Communal latrines	27	6.75

5.3 DEMOGRAPHIC AND LIVELIHOOD PARAMETERS

Demographic and socio-livelihood parameters are indispensable in determining the responses that will support the coping abilities inherent in society against the impacts of changing climate and its variability, in the context of supporting urban environmental security. Accordingly, socio-livelihood parameters such as income, energy use, portable water, and sanitation availability influence the building of resilience and adaptive capacity (Satterthwaite et al., 2020). The previous study looked at household energy and water sources as well as sanitation facilities, which indicate high levels of poverty and vulnerability in the study areas. This section examines results pertaining to household income aspects.

The analysis of the household income per month in the city is important in determining the levels of resilience expected from the household to changing climate impacts. This is in the vein that the building of resilience to changing climate impacts by city dwellers may depend on the levels of income generation in the households (Satterthwaite, 2008; World Bank, 2015). Thus, the study assessed the household income per month as shown in Table 5.12 below.

The results show that only one household's monthly income was less than 50 US dollars equivalence, while 19% of the households had a monthly income between 51-100 US dollars equivalence and 18.25% had a monthly income of between 101-150 US dollars equivalence. Furthermore, 18% of the households had a monthly income of between 151-200 US dollars equivalence, while 44.5% was above 201 US dollars equivalence. The average (mean) monthly household income of respondents was calculated to be 195.2 US dollars equivalence. The standard deviation was 1.182 to the mean indicates that household monthly income from the study are relatively close to the mean value of US\$195.2.

Table 5.12: Household income per month of respondents (n=400)

Household income per month (US Dollar equivalence)	Frequency	% of households
< 50	1	0.25
51-100	76	19
101-150	73	18.25
151-200	72	18
> 201	178	44.5
Total	400	100

The average monthly household income of households in this study was below that of research conducted by Salau (2015) on metropolitan Lagos, which was 285.7 US dollars while it was above \$150 specified in the work of Olajide and Lawanson (2014). Access to income (and, more generally, financial assets) is an important component of financial capital identified in the SLA.

The study identified the multiple and diverse sources of income or livelihoods accessed by the households in the study area. Lawanson and Oduwaye (2014) affirm that participation in informality (both economic and social) is an essential part of the coping strategy for the urban poor in the city. Table 5.13 below depicts the sources of income/ livelihoods accessed by the households in the study areas.

The results reveal that in more than half of the households (55.25%), at least one member was involved in trading or private businesses, while in 27.25% of the households, at least one member had formal employment in the private sector. Therefore, trading and private business (which include organised private sector business) were the main livelihoods and income sources in Lagos Mega-city. Also, other notable private businesses included fishing which 14.5% of the households were involved in. Alongside the fishers were the boat transporters, which were 5%, who utilised their boats on the lagoon and water bodies as a source of livelihood. Only 2.75% of the households were employed in governmental organisations.

There were sand miners (in three of the households' surveys in this study) stationed around the lagoon and water bodies in Lagos city. It was observed during data collection that they skilfully scooped sands from underneath the lagoons into their boats in the Mega-city and stationed the sand mass by the coastline for purchase by builders. Those households that engaged in the sales of agricultural products in the study area accounted for 1.75%. A further 3.25% and 9.5% of the households had members who accessed pensions and remittances, respectively. Only one of the households had a member who had social grants. Additionally, 10.75% of the households did not have members who were employed.

Table 5.13: Sources of incomes/ livelihoods accessed by the households (multiple responses) (n=400)

Sources of income/ livelihood accessed by the households in the study area	Frequency	% of households
Employment in government	11	2.75
Formal employment in the private sector	109	27.25
Trading/ business	221	55.25
Sale of agricultural produce	7	1.75
Remittances	38	9.5
Fishing	58	14.5
Pension	13	3.25
Social grants	1	0.25
Boat transporter	20	5
Sand miner	3	0.75
Unemployed	43	10.75

A male focus group discussion participant from Ago Egun, a fishing community that participated in the survey, asserted how changing climate contributed to issues of unemployment in their community. He said:

The government has made most of us unemployed in Ago Egun. We are traditional fishermen. The sand dredging project, alongside changing climate, makes us not catch fish and other aquatic products. The fishes are shifting far away from our water. Therefore, now we are unemployed, desiring a new job to feed our families.

Image 5.2 below shows the boat transporters waiting for commuters along the canal in the Maroko area of Lagos Mega-city, observed during the survey data collection.



Image 5.2: Boat transporters waiting for commuters along the canal in Maroko area of Lagos Mega-city

The financial assets of the respondents were analysed through the identification of the types of financial assets that respondents (and their respective households) had access to. The study found that all the respondents had access to personal cash, while 68.75% had personal accounts, as represented in the Figure below.

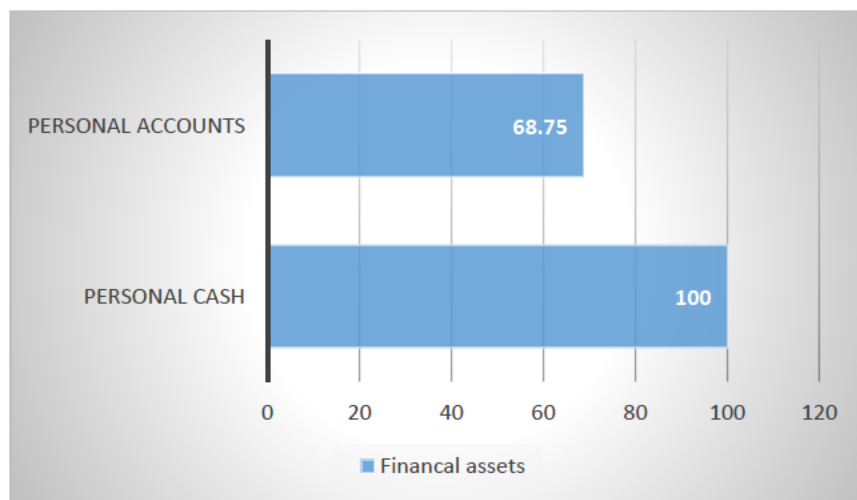


Figure 5.6: Financial assets of the respondents (n=400, in %)

Fisher and Rennie (2017) and Isuku and Nwafor (2019) note the importance of financial capital. While respondents have personal accounts and access to cash, it is important to note that none of the households indicated loans. Additionally, the household survey did not probe the amounts of personal cash respondents had. However, participants during the focus group discussions indicated that most households lived ‘*day-to-day and month-to-month*’, not being able to have any financial savings. Accumulating financial capital is crucial to cope with changes and deal with vulnerabilities, including those associated with climate variability and change, to enhance livelihood outcomes (Wei et al., 2016) and diversify livelihood strategies (Kassa, 2019; Lax & Krug, 2013). Diversifying livelihood strategies is evident in the study areas, with some households having more than one source of income.

The study analysed the external contributions to households in Lagos Mega-city that may support the residents' livelihoods and enhance their resilience to changing climate and encourage their urban environmental security. Table 5.14 depicts the external contributions to the households in this study.

Table 5.14: External contributions to the households (n=400)

External contributions	Frequency	% of households
Contribution from government	43	10.75
Nothing from government	357	89.25
Total	400	100

Only 10.75% of the respondents affirmed that they received contributions from the government to their households. They identified free primary and secondary education provided by the state government as support to the households. The majority of the respondents (89.25%) stated that they did not receive any contributions from the government. All the respondents indicated that there had not been any monetary contribution by the government to their households. This indicates that government support is limited. It is important to note that none of the respondents stated other contributions from NGOs, religious or philanthropic organisations. Support from the government and other organisations is deemed to be an important component of social capital. This type of social capital identified in the SLA (Kassa, 2019) is limited in the study areas.

5.4 THE EXTENT OF THE AWARENESS OF CHANGING CLIMATE AND ITS VARIABILITY IN THE STUDY AREA

Awareness of changing climate and its variability in the study area is crucial for building resilience and encouraging urban environmental security. This is because changing climate has been suggested to intensify new and existing risks for the human and natural environment in cities and the world as a whole (IPCC, 2014b). Hence the assessment of the extent and levels of awareness for a growing community is essential in enhancing public engagement and adoption of veritable approaches that will encourage the building of resilience and climate adaptation (Whitmarsh & Capstick, 2018). This is in the context that past studies have shown that the levels and the extent of changing climate awareness are not the same in different parts of the world (Lee et al., 2015). Also, the perceptions and levels of awareness of changing climate may vary for different communities because of their experiences, vulnerability, and socio-economic characteristics (Elias, 2018). Consequently, evidence has suggested that awareness of changing climate, such as extensive flooding, encourages participation in adaptation and mitigation approaches (Sullivan & White, 2019). The respondent's perceptions of what they understand of climate variability and change are represented in Table 5.15.

When the respondents were asked what they understood by climate variability and change, only a few respondents (2%) claimed they did not know about it. The majority of the respondents (94%) claimed climate variability and change was temperature increase, while 67.5% stated it was late and erratic rain and 67.75% indicated it was a frequent natural disaster such as a flood. Furthermore, 81% of the respondents stated that climate variability equals the change in seasons, 17% claimed it was low crop yields, 8.5% said it was the death of livestock and 4.75% indicated it was a storm.

Table 5. 15: Respondents' perceptions of what they understand by climate variability and change (n=400) – affirmative responses

Understanding of climate variability and change	Frequency	% of respondents
Do not know	8	2
Temperature increase	376	94
Late and erratic rains	204	51
Frequent natural disasters such as floods	271	67.75
Change in seasons	324	81
Low crop yields	68	17
Death of livestock	34	8.5
Others (such as storms)	19	4.75

The responses show that respondents referred to the multiple characteristics associated with climate change, especially the prominence of extreme weather events and variables as impacts on livelihoods. Additionally, the participants in the focus group discussions and the key interviews conducted also expressed their awareness of changing climate linked to weather-related changes and their impacts. Furthermore, one of the elderly (above 70 years old) focus group discussion participants in Ajegunle community described changing climate as *'too much rainfall that is witnessed nowadays which was not the experience in those days'*. Similarly, a participant in the focus group discussion in Bariga community said it was an *'increase in heat, increase in the intensity of rainfall and excessive flooding that we always experience now'*. IPCC Press (2022) and Toole, Klocker and Head (2015) state that the understanding of the concept of climate variability and change by the stakeholders is essential in the development of the processes for amelioration, adaptation, and mitigation of the impacts of changing climate in every society.

5.4.1 Respondents' levels of awareness of change in the annual patterns of climate parameters of Lagos Mega-city

The study examined the awareness levels among the respondents about changes in the annual patterns of climate parameters in Lagos Mega-city. These were done for rainfall patterns, temperature patterns, frequency of flooding, and coastal erosion. Sullivan and White (2019) surmise that there may be a gap between the public and the expert's perceptions of issues about changing climate. Analysing the respondents' perceptions of the levels of awareness of the change

in annual patterns of climate parameters may be a veritable strategy for communicating its impacts as well as the mitigation and adaptation approaches to be engaged (Lund, 2019; Capstick et al., 2015). Figure 5.7 below depicts respondents' perceptions of the levels of awareness of change in the annual patterns of climate parameters in Lagos Mega-city.

The result revealed that the majority of the respondents (88.75%) affirmed they were aware of changes in the annual patterns of rainfall, while only 4.25% rejected this assertion and 7% of the respondents indicated that they did not know about it. Concerning temperature, the majority of the respondents (88.5%) affirmed there were levels of awareness of change in its annual pattern, while fewer respondents (5.5%) denounced the assertion and about 6% stated they did not know about the issue. The majority of the respondents (92%) affirmed there were levels of awareness of change in the annual pattern of the frequency of flooding (often associated with extreme rainfall events), while 3.25% rejected the assertion and 4.75% said they did not know of the issue.

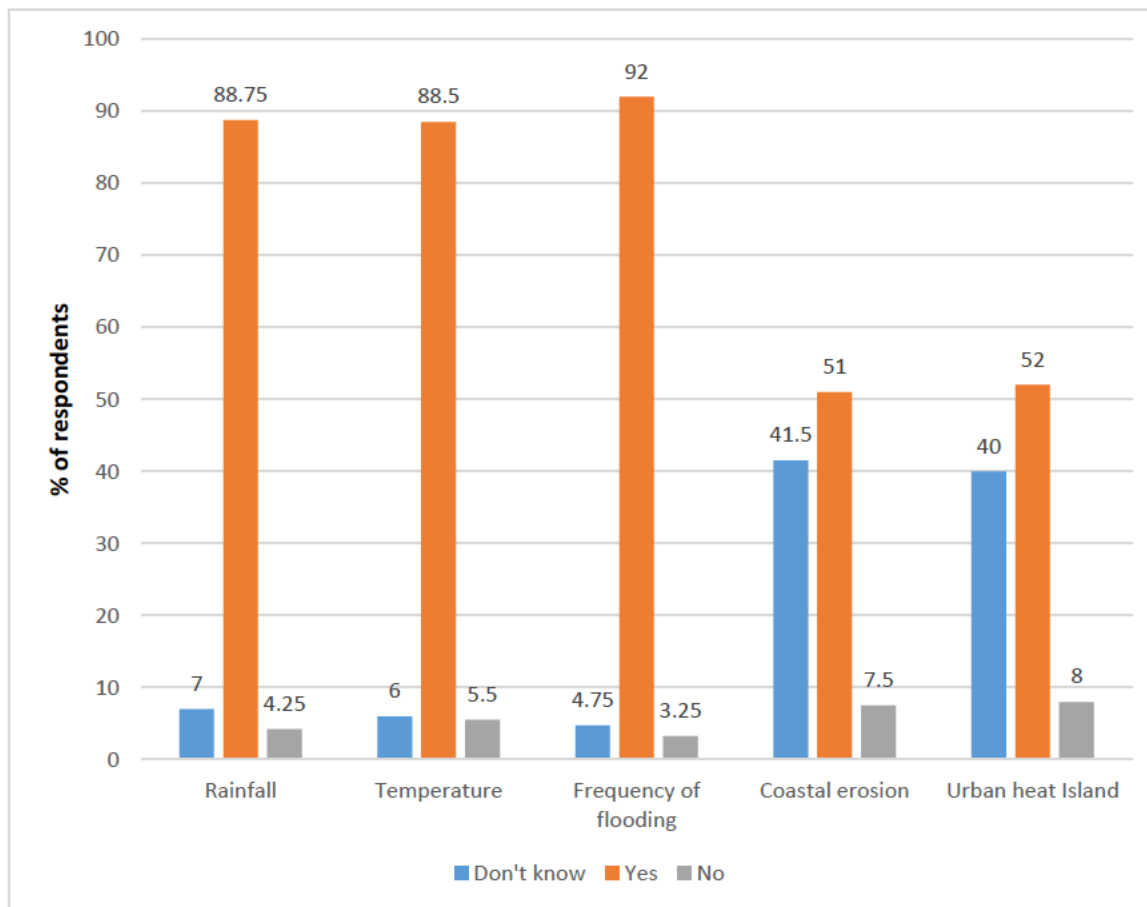


Figure 5.7: Respondents' perceptions of the levels of awareness of change in the annual patterns of climate parameters in Lagos Mega-city (n=400, in %)

The responses resonate with findings in the literature that severe rainfall is likely to inform people's perceptions of climate change as one of the most visible and tangible experiences of changes (Adewale et al., 2017; Ping et al., 2017; Riedy, 2016) and that increased rainfall and flooding is evident in Lagos Mega-city (Adelekan, 2009; 2010; Adelekan et al., 2015; Adelekan, Johnson, Manda, Matyas & Mberu, 2015; Cirella & Iyalomhe, 2018; Lagos State, 2020; Shiru et al., 2019).

Regarding coastal erosion, just about half of the respondents claimed they were aware of changes in its annual patterns, while 7.5% did not share this assertion and 41.5% stated they did not know about it. For urban heat island, about half of the total respondents (52%) affirmed they were aware

of changes in its annual pattern, while 8% of the respondents denounced the assertion and 40% indicated that they did not know. The lower proportions of respondents who were aware of coastal erosion and the urban heat island effect resonate with earlier assertions that people tend to be more aware of more direct and visible aspects of climate change such as rainfall and flooding. Todaro, Testa, Daddi and Iraldo (2021) surmise that the perceptions and awareness of changing climate and climate variability are significant factors in understanding climate risks and essential in the development of strategic climate adaptation actions. Hoa et al. (2021) infer that the awareness and understanding of changing climate and climate variability do not translate directly into action but influence and promote successful household adaptive capacity through access to information and management of resources for effective responses.

5.4.2 Respondents' levels of awareness of the physical changes in the intensity of the annual climate parameters of Lagos Mega-city in the recent years (0 to 5 years) as compared to 5 years and above

The study assessed the respondents' levels of awareness of the physical changes in the intensity of the annual climate parameters in Lagos Mega-city in recent years (0 to 5 years) as compared to 5 years and above (Table 5.16 below). The results indicate that the majority of the respondents (88.75%) perceived that there was a physical change in the intensity of rainfall in their communities in recent years (0 to 5 years) when compared to 5 years and above, while 4.25% of the respondents felt that physical changes in the intensity of rainfall in their communities did not occur, and 7% claimed they did not know about it. In relation to the temperature in the city, the majority of the respondents (88.5%) affirmed that there was a physical change in the intensity of temperature in their communities in recent years (0 to 5 years) when compared to 5 years and above while 5.5% stated that there was no change and 6% claimed that they did not know about it. Likewise, slightly more than half of the respondents (51%) perceived there was a physical change in the intensity of the coastal erosion in their communities in the Lagos Mega-city in recent years (0 to 5 years) when compared to 5 years and above while 7.5% declared that they were not aware and 41.5% stated they did not know.

Furthermore, about half of the total household respondents (52%) perceived there had been a physical change in the intensity of the urban heat island in the city, while 8% indicated that they were not aware of changes and 40% indicated they did not know. Additionally, the majority of the respondents (92%) indicated that there was a change in the frequency of flooding in their communities in recent years (0 to 5 years) when compared to 5 years and above, while 3.25% stated no and 4.75% said they did not know. The findings reveal that changes in the intensity of rainfall, temperature and the frequency of flooding had considerably higher levels of awareness among the respondents than other parameters that were analysed. This may be due to increased perceptions and awareness of the impacts of changing climate by the residents because of recurrent excessive flooding events that were witnessed in the city in recent years (Adelekan, 2016; Adelekan & Asiyani, 2015; Elias, 2018) as well as that these aspects are tangible and experienced directly. Also, the participants during the focus group discussion identified heavy rainfall, massive and destructive floods, high temperatures, and heatwaves (too much sunshine) as common physical changes in the annual climate parameters of the city. The results from the above (both quantitative and qualitative) concur with the analytical study carried out by Abolade, Adigun, Adetunji, Oluniran and Oyediran (2019) for the years 2003 to 2012 in Eti-Osa local government of Lagos State when they revealed noticeable, observable changes in climatic parameters, especially rainfall and temperature. The knowledge and understanding of the perceptions of the public to the impacts of changing climate are vital to inspiring successive mitigation and adaptation procedures (Sullivan & White, 2019).

Table 5.16: The respondents’ levels of awareness of the physical changes in the intensity of the annual climate patterns of Lagos Mega-city in the recent years (0-5 years) as compared to 5 years and above (n=400)

Climate parameters	Do not know (%)	Yes (%)	No (%)
Rainfall	7	88.75	4.25
Temperature	6	88.5	5.5
Frequency of flooding	4.75	92	3.25
Coastal erosion	41.5	51	7.5
Urban heat Island	40	52	8

5.4.3 The extent or degree of contributions of some socio-community features to climate variability and change

This section aims to quantify, through the respondents' perceptions, the extent or degree of the contribution of some socio-community features to climate variability and change in the city. These are socio-community features that commonly exist in growing cities, as noted in the literature review. These include air pollution, land pollution, water pollution, increase in human population, poverty, use of fossil fuels, etc. However, their contributions were examined based on their ability and potential to increase the concentrations of greenhouse gases in the atmosphere, which may enhance global warming. Hence, the assessment of the environmental awareness, behaviour, and degree of these socio-community features' contributions to climate variability and change in the study area is indispensable in the formulation of climate actions, sustainable urban policy, and approaches to be engaged in its communities against changing climate issues (Sau, Weng & Ahamad, 2016; Sullivan & White, 2019; Whitmarsh & Capstick, 2018). Therefore, it is crucial in the attainment of urban climate security. Table 5.17 below represents the household respondents' rating of the extent or degree of contributions of some socio-community parameters to climate variability.

Table 5.17: The rating of respondents’ perceptions of the extent or degree of contributions of some socio-community and environmental features to climate variability and change (n-400, in %)

Socio-community and environmental parameters						
	Do not know	Not important at all	Slightly important	Important	More important	Very important
Air pollution	61	4.75	2	4.25	7.75	20.25
Land pollution	64.5	11.5	2.75	3.75	7.25	10.25
Water pollution	63.25	11.75	2.5	4.25	6.75	11.5
Clearing/ removal of trees	49	0.75	0.25	1.5	4	44.5
Use of fossil fuels	63.5	4.25	0.75	3.75	4.25	23.5
Genetically modified crops	81.75	16.5	-	0.75	0.75	0.25
Hazardous wastes	76.75	14.5	2	1.75	2.25	2.75
Loss of wildlife	82.25	14.75	2	0.25	0.25	0.5
Ozone Depletion	75.75	11.25	5.25	5.25	0.75	1.75
Use of pesticides and herbicides	73.25	9.5	4.75	6.75	3	2.75
Poor farming practices	68.5	6.75	4	7.5	4.75	2.75
Increasing human population	58.25	10	3.75	5.25	3.25	19.5
Increasing poverty	60.75	15.75	3.5	4.5	2.75	12.75
Traffic congestion	61.25	12.25	5.25	7.75	5	8.5

The study found that more than half of the total household respondents in the survey (61%) affirmed that they did not know the extent of the contribution of air pollution to changing climate and climate variability. Also, 4.75% claimed it was not important at all, while 2% stated it was slightly important and 4.25% indicated it was important. Only 7.75% said it was more important and 20.25% affirmed it was very important. On the contrary, there is evidence in the literature, as shown by Cubasch et al. (2013), Perera (2017) and IPCC (2013), that air pollution contributes to changing climate and climate variability. Furthermore, previous studies have indicated the contributions of air pollution to changing climate through emissions of gases which include CO₂, which is a foremost driver of changing climate (Perera, 2017). Lagos Mega-city is the most industrial part of the country Nigeria having 70% of the country’s economic activities with diverse

sources of air pollution, which includes vehicular emissions from its numerous vehicles and commercial buses, emission from fossil fuels, and chemical activities from industries and dumpsites, etc. (Komolafe et al., 2014). Therefore, knowledge and understanding of the levels of air pollution are essential in the city's sustainable environmental practices that will encourage adequate climate actions that are expected to enhance climate security.

Out of all the household respondents, 64.5% said they did not know about the contribution of land pollution to climate variability and change in the city, while 11.5% claimed it was not important at all and 2.75% indicated that it was slightly important. Furthermore, 3.75% affirmed that it was important, while 7.25% stated that it was more important and 10.25% claimed it was very important. The survey indicates that the majority of the respondents claimed they did not know land pollution's contribution to climate variability and change in the city. Subsequently, IPCC (2019) surmises that changes in the conditions of land contribute to changing climate while changing climate also exacerbates the process of land degradation. In addition, there is evidence in the literature that degraded land releases soil carbon alongside nitrous oxide into the atmosphere, making it a big contributor to climate variability and change (International Union for Conservation of Nature [IUCN], 2015).

On water pollution's contribution to climate variability and change, 63.25% of the respondents claimed they did not know. That means they do not know the extent of its contribution. Furthermore, 11.75% claimed that it was not important at all, while 2.5% affirmed that it was slightly important, 4.25% indicated that it was important, 6.75% stated that it was more important, and 11.5% agreed that it was very important. However, Varady et al. (2016), Zadawa and Omran (2018), Hobbie and Grimm (2020), van Ginkel (2018) and Mukwirimba et al. (2022) related the changing climate and the issue of water insecurity and the process of population growth which is indicative of the need for adequate and sustainable water management for city dwellers in this climate variability era. On the other hand, water pollution may contribute to a change in the city's climatic conditions through the generation of greenhouse gases that will produce the greenhouse effect from the toxic chemicals or its by-products from mostly industrial effluents (Inyinbor et al., 2018).

Similarly, on the contribution of the clearing or removal of trees to climate variability and change, 63.5% of the respondents said they did not know, 4.25% indicated that it was not important at all, while a negligible percentage (0.75%) affirmed it was slightly important, 3.75% claimed it was important, 4.25% stated that it was more important and 44.5% declared it was very important. Carter et al. (2014) echo that process of tree removal is an important variable that determines the future of changing climate and the levels of greenhouse emissions. Therefore, the clearance or removal of trees is implicated in increasing atmospheric CO₂ (greenhouse emissions), resulting in the alteration of mass-energy balance, which eventually encourages changing climate (Longobardi, Montenegro, Beltrami & Eby, 2016). Therefore, the changes in trees or forest cover through deforestation, afforestation, and reforestation always have impacts on changing climate (IPCC, 2019).

On the contribution of the use of fossil fuels to climate variability and change in the city, 63.5% of the respondents said they did not know, 4.25% claimed it was not important, while a negligible percentage (0.75%) declared it was slightly important, 3.75% affirmed that it was important, 4.25% claimed it was more important and 23.5% affirmed that it was very important. Scientific knowledge identifies the burning and use of fossil fuels as one of the drivers of changing climate (Perera, 2017). Likewise, on the use of genetically modified crops in the city, about four-quarters of the respondents (81.75%) claimed they did not know about it, 16.5% claimed it was not important, while 0.75% claimed it was important, 0.75% affirmed it was more important and one respondent stated that it was very important. However, there is currently not yet a fixed position taken by scientists on the contribution of genetically modified crops to climate variability and change at present, though some studies say it is beneficial to the environment or carbon footprint while others say it is adverse (Brookes & Barfoot, 2018; Zilberman & Hollands, 2018).

Similarly, on the contributions of hazardous waste to climate variability and change in the city, 76.75% of the respondents claimed they did not know about it, while 14.5% of the respondents said that it was not important, 2% indicated that it was slightly important, 1.75% declared that it was important, 2.25% affirmed that it was more important, and 2.75% declared that it was very important. Wastes such as biodegradable wastes are known to decompose to methane and CO₂, which are veritable greenhouse gases. However, most wastes, including hazardous waste, are disposed of through high temperatures or using incinerators in cities, thus they end up increasing

their carbon footprint (Rizan, Bhutta, Reed, & Lillywhite, 2021). Therefore, hazardous waste is part of the contributor to climate variability and change.

Also, on the contributions of the loss of wildlife to climate variability and change in the city, 82.25% of the respondents claimed they do not know, while 14.75% affirmed that it is not important at all, 2% agreed that it is slightly important, a negligible percentage (0.25%) affirmed it was more important, and 0.5% claimed it was very important. Wildlife is the main terrestrial biodiversity in the world whose loss may have a profound negative effect on their environment since they are indispensable in the maintenance of a healthy forest through the dispersals of seeds that are vital in the growth of vegetation (Prävālie, 2018). Hence, the loss of wildlife (defaunation) has the potential to accelerate global warming by wearing down the forest's carbon-storing capacity (Ripple et al., 2015). However, the majority of the household respondents claimed they did not know about the implication of the loss of wildlife on changing climate. This necessitates the need for continued wildlife conservation, particularly raising awareness about its importance among communities.

The contributions of the depletion of ozone to climate variability and change were also assessed through the household respondents' perceptions. About three-quarters (75.75%) of the respondents claimed they did not know about the contributions of the depletion of ozone to climate variability and change, 11.25% affirmed that it was not important at all, 5.25% claimed it was slightly important, 5.25% declared that it was important, 0.75% stated it was more important and 1.75% acknowledged that it was very important. Thus, the majority of the respondents indicated they did not know about the contributions of the depletion of ozone to climate variability and change. However, changes in stratospheric ozone over some period of years have implications on changing climate apart from its unavoidable implication on human and ecosystem health (Barnes, Williamson, Lucas, Robinson & Madronich, 2019). Thus, the understanding of the city residents needs to be improved about ozone depletion to support its sustainable management.

The survey showed that 73.25% of the household respondents in the city affirmed through their perceptions that they did not know of the contributions of the use of pesticides and herbicides to climate variability and change, while 9.5% claimed it is not important at all, 4.75% claimed that it is slightly important, 6.75% acknowledged that it is important, 3% stated that it is more important

and 3% declared that it is very important. Again, the majority of the respondents did not know of the contributions of the use of pesticides and herbicides to climate variability and change. However, previous studies have shown that the use of pesticides and herbicides as agrochemicals contribute to greenhouse effects and global warming, which encourage changing climate (Shi, Guo, Ning, Lou & Hou, 2020; Ukhurebor, Aigbe, Olayinka, Nwankwo & Emegha, 2020).

Furthermore, the household respondents' perceptions were assessed on the contributions to climate variability and change by poor farming practices in the city. Slightly more than two-thirds of the respondents (68.5%) claimed that they did not know that poor farming practices can contribute to climate variability and change, while 6.75% claimed it is not important at all, 4% said that it was slightly important, 7.5% affirmed that it was important, 4.75% declared that it was more important and 8.75% claimed it was very important. Poor farming practices are shown in literature as a contributor to changing climate with the use of fertilisers and other agrochemicals to increase yields, except only when the farming practice is improved to reduce the carbon footprint (Liang et al., 2014). Furthermore, as shown by Corwin (2020), climate variability and change have substantial impacts on agriculture and food production, which contributes to food insecurity that leads to unsustainable farming practices and the use of biodiversity that causes climate variability and change. The intricate relationships between land use (especially those directly linked to livelihoods and food security) and climate variability and change are generally not understood by the respondents. This was also noted by one of the key informants who stated that *'people are experiencing climate change but they tend not to be aware of the various factors that cause climate change, including the activities that they are involved in'*.

Additionally, the household respondents' perceptions were also assessed on the contributions of the increasing population to changing climate and its variability. More than half of the respondents (58.25%) claimed that they did not know whether the increasing human population contributes to changing climate and climate variability, while 10% of the respondents declared that increasing the human population was not important at all, 3.75% of the respondents affirmed that it was slightly important, 5.25% stated it is important, 3.25% claimed it was more important and 19.5% affirmed that it was very important. Generally, more than half of the respondents claimed that they did not know whether the increasing human population contributes to changing climate and climate variability. However, increases in the human population are a veritable driver of changing climate

through patterns of consumption, affluence, and increasing technology (Rosa & Dietz, 2012). Thus, the demands for land and forest, mostly in growing urban and cities, lead to changes in land use, affecting environmental carbon storage (Brandt et al., 2017; Yang et al., 2020). An urban environment such as Lagos Mega-city, due to its continuously growing population, is also a hotspot for changing climate vulnerability (Milesi, 2020). Sustainable urban agricultural practices that need to be encouraged can be a pathway to climate mitigation and adaptation, contributing to livelihood and food security as well as environmental/ biodiversity security (Artmann & Sartison, 2018; Kingsley et al., 2021).

Moreover, 60.75% of the household respondents declared that they did not know whether an increase in poverty contributes to changing climate and climate variability, while 3.5% affirmed that it was not an important contributor to climate variability and change, 4.5% declared that it was slightly important, 2.75% stated that it was important, another 2.75% affirmed it was more important and 12.75% acknowledged that it was very important. However, there have been direct and indirect relationships between changing climate and poverty in society, connected to how people fall and escape from poverty (Hallegatte, Fay & Barbier, 2021) that is linked to levels of vulnerability as noted in the literature (United Nations, 2016a). Thus, the perceptions of its contribution and interrelatedness are essential in a city's sustainable development, especially given the prominence of urban poverty in most developing countries, as indicated by Broto et al. (2015), Kuddus et al. (2020), Sun et al. (2020) and Williams et al. (2019). Poverty also influences the types of energy sources people use, as discussed earlier, as well as livelihood practices that contribute to climate variability and change. Given the high levels of poverty associated with socio-economic vulnerabilities in Lagos Mega-city, it is of concern that the majority of the respondents do not see the link between poverty and climate variability and change.

Likewise, 61.25% of the household respondents affirmed they did not know whether traffic congestion contributes to climate variability and change, while 12.25% indicated that it was not important at all, 5.25% stated that it was slightly important, 7.75% claimed it was important, 5% declared that it was more important, and 8.5% acknowledged that it was very important. Road transport which comes along with traffic congestion in most densely populated cities constitutes a high level of carbon footprint which is a driver of changing climate (Cong et al., 2018; Gurney, Romeo-Lankao & Seto, 2015). Therefore, the level of understanding of one of the drivers of

changing climate in the city is low since the majority of the respondents indicated a lack of awareness of transportation's contribution to climate variability and change. This is particularly relevant in the Lagos Mega-city context, where Maduekwe et al. (2020) show that the transportation sector of Lagos is responsible for about 50% of the greenhouse gas emissions in Nigeria.

Summing up the results, it could be seen that most of the household respondents interviewed have limited or no understanding or knowledge of the extent or degree of contribution of various socio-community features to climate variability and change. This indicates there is less knowledge about what contributes to increasing climate variability and change, including aspects that directly impact their lives, such as poverty or practices that they are involved including the use of fossil fuels and generating waste, by the majority of the household respondents. On the other hand, they did not grasp or understand climate and how their actions may contribute to increasing the change and, invariably, their vulnerability. Therefore, the need for increased awareness of the contributing factors associated with climate variability and change is critically important. It is also important to note that many of the contributing factors are interrelated. For example, poverty influences the use of fossil fuel-based energy use, land clearing for the construction of homes (often in vulnerable locations) and the poor management of waste. The multidimensionality of contributing factors is, therefore, also important to consider. In general, knowledge and understanding of the causes of climate variability and change are essential for the development of climate actions that will enhance climate security.

5.5 THE EXTENT AND NATURE OF CLIMATE VARIABILITY AND CHANGE IMPACTS ON URBAN ENVIRONMENTAL SECURITY OF LAGOS MEGA-CITY IN NIGERIA

Climate parameters are indispensable in determining the climate security and urban environmental security of a location. Hence, the security of the city and urban environment has been threatened by climate variability and changing climate leading to increasing magnitude and frequencies of weather and climate extremes that magnifies the existing risks (IPCC Press, 2022; McDonald,

2013; Smith et al., 2019). Waldinger (2022), providing evidence from the little ice age from 1600-1850, identifies the negative economic impacts in the long-term associated with changing climate. This study established earlier, through respondents' levels of awareness of the changes in nature and intensity of climate parameters such as rainfall, temperature, and urban heat island that were experienced in Lagos Mega-city in recent years (0 to 5 years) when compared to 5 years and above. Table 5.18 below depicts the respondents' perceptions on the intensity of the changes in the annual climate parameters in Lagos Mega-city in recent years (0-5 years) when compared to 5 years and above

Table 5.18: Respondents' perceptions of the intensity of the changes in the annual climate parameters in Lagos Mega-city in the recent years (0-5 years) when compared to 5 years and above (n=400, in %)

Climate parameters	Do not know/ not applicable	No change	Increasing	Decreasing
Rainfall	8	6	85.25	0.75
Temperature	6.25	6	87.25	0.5
Frequency of flooding	5.5	2.5	92	-
Coastal erosion	38.75	10.75	50.25	0.25
Urban heat Island	37.75	11.25	51	-

The findings reveal that the majority of the household respondents (85.25%) affirmed that the intensity of change in rainfall was increasing in Lagos Mega-city, while 0.75% stated that it was decreasing, 6% declared that there was no change and 8% claimed they did not know. Likewise, the majority of the respondents (87.25%) affirmed that the change in the intensity of temperature was increasing in Lagos Mega-city while 0.5% stated it was decreasing, 6% expressed there was no change and 6.25% said they did not know. Similarly, 92% of the respondents claimed that the intensity of the change in the frequency of flooding was increasing, 2.5% stated there was no change and 5.5% said that they did not know. Individual physical assets such as buildings and household properties are always subjected to damage during excessive floods in the city (Olajide & Lawanson, 2014). Similarly, 50.25% of the respondents claimed the intensity of coastal erosion in the city was increasing, 10.75% said there was no change and 38.7% claimed they did not know.

Also, about half of the total respondents (51%) acknowledged that the intensity of change in UHI was increasing in their communities while 11.25% declared that there was no change and 37.75% stated they did not know. The results generally support earlier responses that reveal that residents are aware of and are experiencing climate-related changes, especially in relation to the more tangible aspects such as rainfall and flooding. The intensity of changes is important to consider since it reveals the perceived devastation or extent of impacts (Akbari et al., 2016). The perceptions of the respondents align with scientific results in the literature that indicates the increased intensity of climate variability (Babalola & Akinsanola, 2016; Fasona et al., 2019; Hobbie & Grimm, 2020; UNDP, 2013a).

Likewise, the study assessed the respondents' perceptions of the span/ length of the annual rainfall season in the city in recent years when compared to 5 years and above. The results indicated that 69% of the respondents affirmed that the annual rainfall season of Lagos Mega-city was longer in recent years (0 to 5 years) when compared to 5 years and above, while 12.5% stated that it was shorter and 7% declared that there was no change in the annual rainfall season. However, 11.5% said that they do not know the span of the annual rainfall season in recent years (0 to 5 years). This is represented in Figure 5.8 below.

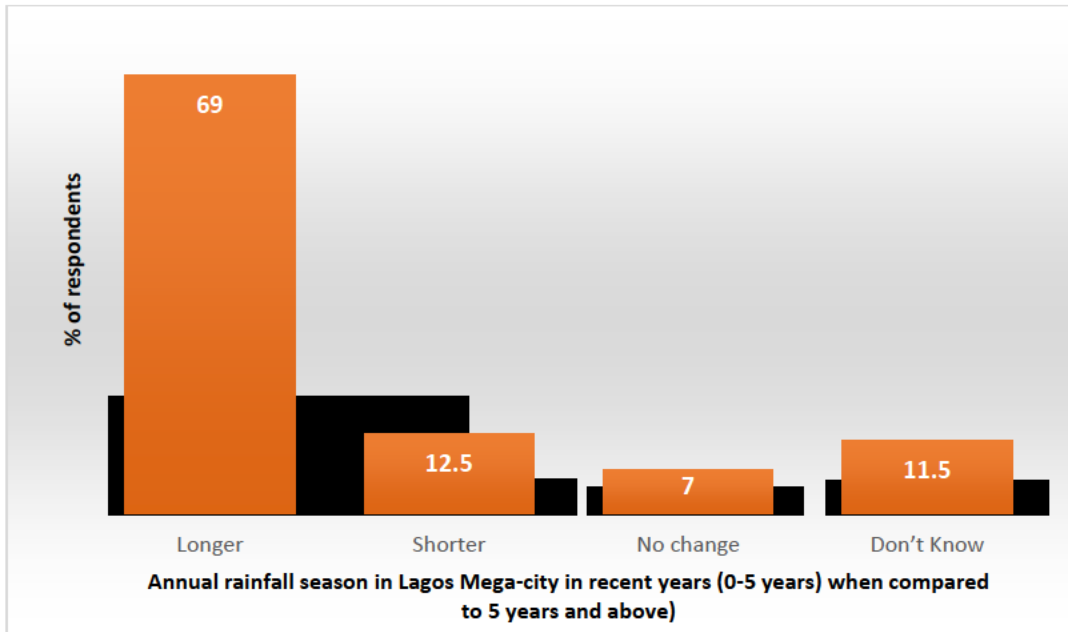


Figure 5.8: Percentage of the total respondents' perceptions of the annual rainfall season in Lagos Mega-city in the recent years (0-5 years) when compared to 5 years and above (n=400, in %)

During the three focus group discussions, most of the participants agreed that there has been changing climate with variabilities in weather conditions which have affected the amount and timing of rainfall. As one of the participants stated: *'rain does not normally fall in October and November. The period was always for harmattan season but nowadays it falls. Also, the rain that falls is more than what we used to have on those days'*. One of the key informants from the Lagos State Ministry of Environment and Water Resources also raised concern about changing climate and climate variability in the city: *'Changing climate is associated with variability in rainfall, temperature, sea level and coastal erosion with corresponding negative impacts on the residents'*.

In addition, participants during the focus group discussions emphasised that changing climate at different times had created extremes which included excessive floods during torrential rainfalls in wet seasons in Lagos Mega-city had led to socio-economic and health insecurities. For example, a male participant that was a fishmonger residing alongside the coastline during the focus group discussion highlighted his perception of the effect of changing climate on their socio-environment. He stated:

Erosion is taking away the sands by the sea. Floods of water come to the shore to take the sand away. Sometimes trees, especially coconuts that were by the seashores and lagoons, fall on their own. Changing climate has affected fish and crayfish catch. We now catch little crayfish since the volume of water has increased.

Another participant during the focus group discussion emphasised the socio-economic implications of flooding in the city stating:

Displaced people, as a result of the effects of extreme events such as flooding, do migrate and look for another place to stay. This is affecting the economic well-being of the people that depend on the water environment for their livelihoods, apart from those that stay in the marginal environment that is always displaced by floods during rainy seasons.

Also, some of the participants during the focus group discussions highlighted the implications of extreme climate events on the health security of the people. One of them said:

*The floods in every place breed mosquitoes that led to recurrent malaria. Our children fall sick regularly. Hospitals are far away from us. People are poor. The government **does not** even know that we exist since no help is provided.*

Furthermore, during a key informant interview conducted with one of the Ministry of Environment workers, a senior environmental officer remarked on the health implications of changing climate in the city. He said:

Rainfalls accompanied by floods caused by changing climate have led to the destruction of infrastructure, which includes buildings. Also, at different times fatal incidences leading to loss of lives have occurred. Similarly, stagnant waters that were created during rainfalls and excessive flooding always increase the risks of water-borne diseases apart from mosquitoes that are bred in stagnated water.

These findings in Lagos Mega-city echo the findings of Ebi et al. (2019) and Reckien et al. (2018) on the negative implications of torrential and excessive rainfall associated with changing climate on the socio-economic and public health systems in urban centres.

5.6 THE EXTENT AND THE NATURE OF CLIMATE VARIABILITY AND CHANGE ON BIODIVERSITY DEPLETION AND URBAN ENVIRONMENTAL SECURITY IN LAGOS MEGA-CITY

The threats of changing climate alongside urbanisation on biodiversity and ecosystems in cities cannot be overemphasised (González-Orozco et al., 2016; Koop & Leeuwen, 2017; Sintayehu, 2018). These threats have been compounded by inadequate preparation for urban growth, which is common in cities in developing nations (Grimm et al., 2008; Wu, 2014). Therefore, Lagos Mega-city, like some developing economy countries' growing cities, was not prepared for its current growth, making its biodiversity and ecosystems susceptible to the threats of urbanisation and changing climate. This study rated the quantities of crop and livestock harvest and assessed the extent and nature of climate variability and change on biodiversity with a focus on the aquatic livestock in the city.

5.6.1 Rating of the aquatic/ ocean species sourced in households of Lagos since the past 5 or more years

The respondents were expected to provide information about the aquatic/ ocean species that were sourced in their households. However, it was found that only 14.5% of the total respondents sourced aquatic species. They were the traditional fishmongers who resided around the coastline of the Lagos lagoon. The study rated the aquatic species sourced by the respondents (responses from only those that sourced aquatic/ ocean species) in the past 5 years. Table 5.19 below depicts the rating of the aquatic/ ocean species sourced in households of Lagos over the past 5 years or more. It is important to note that none of the respondents indicated increased or greatly increased in relation to any of the species. This shows that there is widespread consensus that fish species are perceived to be declining. These results are supported by Weiskopf et al. (2020), Adewale et

al. (2017), Omitoyin and Tosan (2012) and OECD (2014), who indicate declining aquatic species (and related catches). This has serious implications for those households who rely on fishing as a livelihood strategy as well as in poorer households where fish sourced from the lagoon is a key food resource and nutrition.

Table 5.19: Rating of the aquatic/ ocean species sourced in households of Lagos since the past 5 or more years (responses from respondents who sourced aquatic species only) (n=58, in %)

Rating	Bonga fish	Tilapia	Catfish	Crayfish	Shrimp	Crab
Remained the same	1.7	-	-	-	-	-
Greatly decreased	96.6	98.25	98.25	93.1	94.75	84.5
Decreased	1.7	1.75	1.75	6.9	5.25	13.75

The results indicate that 96.6% of the respondents who sourced aquatic species in the past 5 or more years stated that the quantity of bonga fish catch has decreased greatly, while 1.7% indicated it decreased and 1.7% said it remained the same. Also, 98.3% of the respondents that sourced aquatic species indicated that the quantity of tilapia catch had decreased greatly, while 1.7% indicated it decreased. Similarly, 98.3% of the respondents that sourced aquatic species indicated that the quantity of catfish catch had decreased greatly, while 1.75% indicated it decreased. Likewise, 98.25% of the respondents that sourced aquatic species indicated that the quantity of crayfish catch had greatly decreased, while 1.75% indicated it decreased. Similarly, 94.75% of the respondents that sourced aquatic species indicated that the quantity of shrimp catch had decreased greatly while 5.25% indicated it decreased. About 1.75% of the respondents that sourced for crab indicated that their catch has decreased while 84.5% claimed it had decreased greatly and 13.75% stated it remained the same. Therefore, the study shows that there was a decrease in aquatic source species in the past 5 or more years.

The fishmongers in the three focus group discussions overwhelmingly affirmed that there had been decreases in fish and aquatic livestock catch in their respective areas in recent years as compared to what was happening some years ago and this has affected their livelihoods. They acknowledged that the reduction in fish catch had made some of their members, who were mostly the youth,

decide on other jobs instead of fishing which was a traditional job of their clan. One of the fishmongers in his explanation of the present situation when compared to what was happening before said:

Fishes and other aquatic livestock catches have reduced significantly in recent years when compared to about 10 years and above. We now travel far on the water to get fish. It is now becoming difficult to get some fish such as some species of snappers. Also, there is a reduction in some fish species. Shrimp catch has also reduced. The sand dredging is already affecting lives in the water.

The fishmongers who participated in the focus group discussions identified habitat destabilisation/ destruction, sand mining/ dredging, water pollution, invasive species (especially water hyacinths) as well as climate variability and change as the cause of loss of aquatic biodiversity (reduction in some fish species) and decreasing fish catch in the Lagos water environment. The decrease in aquatic stock highlighted by the majority of the household respondents and also participants during the focus group discussions correlate with the assertion of Davies-Vollum, Raha and Koomson (2021), Omitoyin and Tosan (2012) and OECD (2014) that fluctuation and changes in water's physical environment, habitat, changing climate and climate variability have debilitating effects on coastal ecology leading to declines in the quality of aquatic ecosystems.

5.7 THE NATURAL RESOURCES AVAILABLE FOR LIVELIHOODS IN LAGOS MEGA-CITY

Changing climate can threaten human livelihoods and well-being in different parts of the world (Bouroncle et al., 2017; Dube, Moyo, Ncube & Nyathi, 2016; Musinguzi et al., 2020). Low-lying coastal cities like Lagos Mega-city, with their complex urban livelihoods, are particularly susceptible to its threats (Filho et al., 2018). The study assessed the different types of natural resources available for urban livelihoods in the city from the respondents through face-to-face interviews and participants in the focus group discussion. Table 5.20 below depicts the types of natural resources available for livelihoods in the study area in relation to the number of respondents who indicated that households utilised them. Chi-Square tests were undertaken to examine whether there was an association between selected socio-demographic variables (gender, age, education

level and household structure/ materials) and the natural resources available for livelihoods in the study area. No statistically significant differences were found in relation to gender, age and household structure/ materials. However, there were significant differences in relation to level of education and animals being available for livelihoods ($p=.007$), with respondents with higher education having access to animals.

Table 5.20: The natural resources available for livelihoods in the study area (multiple responses) (n=400)

Types of natural resources	Frequency	% of respondents
Ocean	42	10.5
Animals	80	20
Materials	22	5.5
Lagoons	56	14
Freshwater	5	1.25
Aquatic livestock	45	11.25
Others (food - vegetables and fruit - from nature)	5	1.25

The study revealed that 10.5% of the respondents indicated that households utilised the ocean for their livelihoods. It further showed that 4% of the total respondents were utilising ocean resources daily, 2.5 % weekly, 3.75% monthly, and one respondent stated yearly. Also, natural resources from the Lagos lagoons were used by 14.75% of the households interviewed, with 14.25% using the lagoon resources daily as livelihood activities and 0.5% weekly. Also, 11.25% of the households interviewed used aquatic livestock for their livelihoods, with 10.75% using aquatic livestock as livelihood activities daily and one respondent each stated monthly and yearly. Furthermore, 20% of the households interviewed used animals from natural resources for their livelihoods. Only 2% used animals daily, while 2.25% used them weekly, 16.5% monthly, and 0.25% yearly. Two households interviewed utilised freshwater natural resources as their livelihood daily. Also, 1.25% of the households interviewed engaged in extracting vegetables and fruit which they utilised daily. It is important to note that forests and natural vegetation were not identified by any of the respondents. This is mostly because the city's continuous urbanisation and increasing population growth encouraged the occupation and utilisation of the available lands and spaces for the built environment, leading to the continuous loss of city vegetation and forests. This is supported by the literature, as shown by Amberber (2021) and Obudu (2015), that continuous

urbanisation results in a massive change of urban ecosystems within cities which include their landscape structures, compositions and functions. Babalola and Akinsanola's (2016) analysis of the changes in the spatial distribution of some local governments in the Mega-city also indicates that there has been a rapid decrease in the city's vegetation cover in the last three decades. Hussain and Imitiyaz (2019) also note that urban growth is associated with a change in socio-economic and environmental parameters. Similarly, Mohammed (2019), Amberber (2021) and Gao (2017) affirm the deficiency and degradation of natural resources in cities.

Smit and Connolly-Boutin (2016) surmise that the available natural resources in a society have a veritable impact on the people's livelihoods, shaping their adaptation to changing climate and enhancing climate security. Though the urban economy relies mostly on commercial activities (except cities that are in proximity to oil-producing areas), unlike rural economies that rely on natural resources dependent livelihood strategies such as agriculture (Mandere, Ness & Anderberg, 2010; Oduro, Adamtey & Kafui, 2015). In this study, less than one-fifth of the respondents were utilising or relying on different categories of natural resources (for all parameters analysed) in the Mega-city. Reckien et al. (2018) affirm that the opportunities to generate financial and productive assets in cities may be limited when there is little reliance on natural assets that are prime in increasing their productive engagement and could invariably encourage financial capital, which could increase residents' capabilities against changing climate and climate variability implications. The study also examined respondents' perceptions pertaining to how climate variability and change impacted the availability of natural resources in their households and communities more generally in relation to specific attributes, as shown in Table 5.21. The Table indicates the affirmative responses only. Chi-Square tests were undertaken to examine whether there was an association between selected socio-demographic variables (gender, age, education level and household structure/ materials) and perceived climate variability and change impacts on the availability of natural resources in respondents' households and communities generally. Significant differences were found in relation to gender and availability of wood for construction at the household level ($p=.034$ - more male respondents), gender and availability of thatching grass at the community level ($p=.007$ - more male respondents), age and availability of fuelwood at the household level ($p<.001$ - identified by older respondents), age and availability of wood for construction at the community level ($p=.037$ - identified by respondents mainly in the 31-50 years group), educational level and availability of fuelwood at the household level ($p=.014$ - mainly

respondents with primary and secondary completed), educational level and availability of fuelwood at the community level ($p < .001$ - also mainly respondents with primary and secondary completed), educational level and availability of wood for construction at the household and community levels ($p < .001$ - mainly respondents with lower or no formal education), educational level and availability of thatching grass at the household and community levels $p < .001$ - mainly respondents with lower or no formal education), household structure/ materials and fuelwood at the household level ($p = .021$ - mostly respondents who reside in formal structures), household structure/ materials and wood for construction at the household and community levels ($p = .021$ and $p < .001$, respectively - mostly respondents who reside in formal structures), and household structure/ materials and thatching grass at the household and community levels ($p < .001$ - mostly respondents who reside in informal structures).

Table 5.21: Perceived climate variability and change impacts on the availability of natural resources in respondents' households and communities generally (n=400) – affirmative responses

Perceived impacts	Household		Community	
	Frequency	% of respondents	Frequency	% of respondents
Fuelwood is hard to find	24	6	52	13
Decrease in wood for construction	43	10.75	87	21.75
Wells are drier	2	0.5	1	0.25
Decrease in thatching grass	10	2.5	28	7
Decrease in honey	2	0.5	5	1.25
Decrease in the wild animal hunt	4	1	9	2.25
Decrease in wild fruits	8	2	19	4.8
Decrease in fish catch	81	20.25	271	67.75
Decrease in fish species	75	18.75	171	42.75
Decrease in pastures	2	0.5	1	2.5
Soils are infertile	-	-	1	0.25
Others (wells have more water)	4	1	4	1

Among the respondents surveyed, 21.75% of the respondents acknowledged that there was a decrease in wood for construction in their communities, while 10.75% stated the same for their households. Also, 13% affirmed that fuelwood was hard to find for their communities' use, while

6% acknowledged the same for their households' use. In terms of water, only two of the respondents stated that the wells in their households were drier while one respondent stated the same for their communities. Furthermore, four respondents claimed that wells had more water in their households and communities. Additionally, 7% of the respondents stated a decrease in thatching grass availability for their community while 2.5% affirmed its decrease in the households. Modernisation has transformed built structures that make use of construction materials such as wood and thatching grass inconsequential or not in use in many parts of the city. In this study, only respondents who were residing in close proximity to the lagoons used these resources.

In terms of specific natural resources for food consumption, perceived negative impacts were noted. The responses need to be interpreted in the context of earlier findings that show that the use of natural resources among the households surveyed (Table 5.21) was low, linked to limited availability because of rapid development. As noted earlier, the city has experienced increasing urbanisation, which has replaced most natural spaces with built structures. There were negligible responses on wild animals and wild fruits. Specifically, 1% of the respondents stated there was a decrease in wild animals to hunt for their households, while 2.25% stated the same for their communities. Only 2% of the respondents stated a decrease in the availability of wild fruits for their households, while 4.8% indicated the same for their communities. Substantially higher responses were noted in terms of fish resources with 20.25% of respondents affirming that there was a decrease in fish catch for their households, while 67.75% declared the same for their communities. Similarly, 18.75% of the respondents affirmed there was a decrease in fish species for their households, while 42.75% stated the same for their communities. The responses reflect the importance of fish resources in the communities and that the effects on these resources, as indicated by Adewale et al. (2017) and OECD, 2014, are being noted by communities.

The responses of the respondents concerning issues of pastures and soil infertility were negligible, again linked to the lack of availability of natural spaces. Only two respondents affirmed a decrease in pastures for their households, while 2.5% stated the same for the communities. There was no response for soils that were infertile for individual households, while one respondent noted that soils were infertile in the community more generally.

Generally, an insignificant percentage of respondents responded to most of the issues for their immediate households, except in the case of the issues concerning fish catch and fish species where the levels of response were higher because of the proximity of some of the respondent's residence to the lagoons where fish were caught. These findings resonate with the assertion of Omilusi (2020) and Farrington et al. (2002) that city dwellers relate more to the commoditised character of the city, which makes them depend highly on cash income except for specific groups like the fishmongers residing in coastal communities. It is also important to note that, in most cases, there were higher percentages in relation to community compared to immediate household responses. This suggests that although respondents' households may not directly be experiencing negative changes on the natural resource base, the respondents are aware of other households in the community experiencing these changes.

5.7.1 Climate variability and change impacts on agricultural production

Previous literature emphasises the impacts of climate variability and change on agricultural production with adverse impacts on crop yield in different parts of the world (Farooq, Farooq, Akbar, Hassan & Gheewal, 2023; Syed, Raza, Bhatti & Eash, 2022). Making food security to be under threat. The study examined how climate variability and change impacted agricultural production in households and communities in general. Table 5.22 below depicts the impacts of climate variability and change on agricultural production as discussed above.

Table 5.22: Perceived agricultural production climate variability and change impacts on respondents' households and communities in general (n=400)

Perceived impacts	Household		Community	
	Frequency	% of respondents	Frequency	% of respondents
Decrease in crop yield	3	0.75	75	18.75
Decrease in crop variety	4	1	27	6.75
Decrease in livestock numbers	-	-	14	3.5
Reduction in space of land available for crop production	1	0.25	5	1.25
Reduction in space of land available for grazing	-	-	3	0.75
Reduced sale of agricultural produce	2	0.5	14	3.5
Low water supply	1	0.25	3	0.75
No land for farming	170	42.5	174	43.5
I do not know	-	-	100	25

Earlier findings (see Table 5.13 which presents results in relation to household incomes/ livelihoods) indicate that few households (1.75%) surveyed sold agricultural produce. Consequently, few respondents gave their responses on the issues of agricultural production in connection to changing climate in the city. Only three respondents claimed that changing climate has led to a decrease in crop yields in their households, while considerably more (18.75%) indicated the same for their communities. Also concerning the household, 1% of the respondents indicated that changing climate has led to a decrease in crop variety, while 6.75% indicated the same for their community. Similarly, only 3.5% of the respondents indicated changing climate has led to a decrease in the livestock numbers in their communities, with none indicating that this was experienced in their households. Likewise, only one respondent affirmed that changing climate has led to a reduction in the space of land available for household crop production, while 1.25% indicated the same for their communities.

Additionally, three respondents claimed that changing climate led to a reduction in the space of land for grazing in their communities (none in relation to their households). One respondent indicated changing climate has caused a reduction in the sales of agricultural produce, while 3.5% affirmed the same for their communities. Similarly, one respondent indicated that changing climate

has led to low water supply in the households, while three affirmed the same for the communities. Twenty-five percent (25%) of the respondents claimed they did not know how climate variability and change impacted agricultural production in their communities in the city. The main perceived impact was linked to land availability, with 43.5% of the respondents indicating that there was no land for farming in their communities, while 42.5% affirmed the same for their households. This is supported by Taiwo (2016) who emphasises that there is competition, rapid disappearance, and displacement of farming land within the built environment in Lagos Mega-city. This may be because agriculture cannot compete favourably with other urban land use (Obudu, 2015; Orsini, Kahane, Nono-Womdim & Gianquinto, 2015). This trend, together with changes in climate, has drastically decreased the use of city land for agricultural production, impacting on food security for the urban poor (Boretti & Rosa, 2019; Kingsley et al., 2021; Liu & Zhou, 2021). Taiwo (2016) surmises that the rapid disappearance of agricultural land in the city in recent times is making Lagos Mega-city fast becoming a 'food desert'. The rapid disappearance of agricultural land may contribute to the reduction in the number of Lagos Mega-city dwellers who are engaged in agricultural production and impact negatively on its urban food production as only a few responses were received on changing climate and agricultural production in the survey as witnessed in this study.

The study rated the quantity of the crop harvested in the past 5 or more years in Lagos Mega-city households through the face-to-face interviews conducted with the residents. The respondents were expected to provide information about the crop harvested. It was revealed that the majority of the respondents were not growing crops. Only 1.75% of the respondents were involved in crop harvesting. Therefore, out of the household respondents that harvested crops, four respondents harvested Cassava and Yam while three respondents harvested maize, beans, and fruits. However, seven respondents harvested vegetables. Table 5.23 below depicts the rating of the quantity/ amount of crops harvested in the past 5 years in the respondents' households (the responses analysed were from only respondents involved in crop harvesting). The n-values in the second column indicates the number of respondents who indicated that they harvested specific types of crops and it is these respondents who provided a rating.

Table 5.23: Rating of the quantity of crop harvested in the past 5 or more years in respondents' households (responses from only respondents involved in crop harvesting)

Crop harvested	N	% Greatly increased	% Increased	% Greatly decreased	% Decreased
Cassava	4	-	-	25	75
Yam	4	-	-	25	75
Maize	4	-	-	100	-
Beans	3	-	-	100	-
Fruit (for example, mango and orange)	3	-	-	100	-
Vegetables	18	14.25	14.25	28.5	43

Out of the four household respondents that harvested cassava in the past 5 or more years, 25% of the respondents stated that harvest has greatly decreased while 75% claimed it decreased. None of the respondents stated it greatly increased, increased or remained the same. Likewise, out of the four household respondents that harvested yams in the past 5 or more years, 25% of the respondents said that harvest greatly decreased, while 75% affirmed it has decreased. None of the respondents stated it greatly increased, increased or remained the same. For maize, beans, and fruit, all three respondents that harvested them claimed each of them had greatly decreased. However, 18 household respondents claimed they harvested vegetables in the past 5 years or more, 14.25% of them claimed it greatly increased, another 14.25% claimed it increased while 28.5% said it has decreased while 43% stated it has decreased while non said it remained the same.

Likewise, the study rated the quantity of livestock kept in the households in the past 5 or more years in Lagos Mega-city through the face-to-face interviews conducted with the household respondents. Table 5:24 below depicts the rating of the quantity of livestock kept in the past 5 years in the respondents' households (the responses analysed were from only respondents that kept livestock).

Table 5.24: Rating of the quantity of livestock kept since the past 5 or more years in the respondents' households (responses from only respondents that kept livestock) (n=400)

Livestock kept	n-value	Greatly increased (%)	Increased (%)	Remained the same (%)	Greatly decreased (%)	Decreased (%)
Goats	39	2.5	2.5	-	71.75	23.25
Sheep	10	-	-	-	60	40
Rams	7	14.25		14.25	57.25	14.25
Chicken/ Guinea fowl	82	9.8	4.9	2.4	15.9	67.1
Pigs	1	-	-	-	100	-

The result indicated that only about one-fifth (20.5%) of the households surveyed kept livestock in the past 5 or more years. Out of the household respondents that kept livestock past 5 or more years, 82 respondents kept chicken/ guinea fowl. Out of these respondents, 67.1% indicated that the number of chicken/ guineas kept had greatly decreased, 15.9% of the respondents indicated it only decreased, 2.8% said it has remained the same and 4.9% stated it increased while 9.8% said it increased greatly. Thirty-nine (39) respondents kept goats for the past 5 or more years, with 71.75% affirming that the number had greatly decreased, about one-quarter of the respondents said it only decreased, 2.5% indicated it has only increased and another 2.5% said it greatly increased. Out of the ten respondents that kept sheep in the past 5 or more years, four (40%) said it had decreased while six (60%) indicated it decreased greatly.

Out of the seven respondents that kept rams in the past 5 or more years, four (57.25%) of them indicated it has decreased greatly, while one respondent (14.25%) said it only decreased, another respondent claimed it remained the same and one other affirmed it has increased. Only one respondent kept pigs in the past 5 or more years. The respondent asserted that it decreased greatly. In line with this analysis, evidence in the literature as shown by Lawanson, Orelaja & Simire (2016) on peri-urban agriculture in Lagos, indicated that the changing patterns of temperature, rainfall and flooding alongside uncontrolled urbanisation were the main challenges faced in the agricultural production in the Mega-city. Thus, the food security of the city may be impeded by its continuous urbanisation alongside climate-related induced variability and impacts.

5.7.2 Climate variability and change impacts on the socio-economic status of their household and community in general

Increased climate variability and extreme events globally have been suggested in the literature to have adverse impacts on the socio-economic parameters of the people expressed in challenges that include food insecurity, poverty, job loss and displacement (Ebi, 2019; Reckien, 2018; Shimada, 2022; Syed et al., 2022). Based on the above, the study examines through perceptions of the household respondents the climate variability and change impacts on the effects that were created by their socio-economic parameters. Hence, the results in Table 5.25 below depict the perception of the household respondents on how climate variability and change impact the socio-economic status of their household and community in general.

Table 5.25: The perception of the household respondents on how climate variability and change impact the socio-economic status of their household and community in general (n=400) – affirmative responses only

Perceived socio-economic impacts	Household		Community	
	Frequency	% of respondents	Frequency	% of respondents
Lack of help from neighbours	41	10.25	77	19.25
Travelling long distances to get water	3	0.75	3	0.75
Travelling long distances to get fuelwood	2	0.5	9	2.5
Looking for other jobs	69	17.25	220	55
Spending time doing extra jobs	25	6.25	36	9
More strife, petty jealousies/ conflict	36	9	89	22.25
Loss of family ties due to outmigration	70	77.5	174	43.5
Higher levels of crime	77	19.25	127	31.75
Experiencing hunger-related diseases	50	12.5	105	26.25
Experiencing water-related diseases	61	15.25	144	36
Children not attending school	53	13.25	144	36
Less family gatherings as time is spent fending for food	17	4.25	31	7.75
More social gatherings to discuss issues	2	0.50	3	0.75
More attention by government and NGOs	3	0.75	-	-

The study revealed that 10.25% of the respondents affirmed that the impact of climate variability and change made their households did not receive help from their neighbours and 19.25% claimed the same for their community. However, three respondents stated that the impact of climate variability and change made their households and community travel long distances for water. Also, 17.25% of the respondents claimed that changing climate led to an increase in job searching of members of the households while more than half (55.25%) of the respondents affirmed the same

for their communities. An elderly man above 60 years old who was a fishmonger living in the marginal community in the focus group discussion said:

The decrease in the number of fish caught caused by changing climate is making some of our community members not send their children to school again. They are now making less money from fishing. Some of them are now unemployed desiring new jobs to feed their families. Even when they prefer their children to be in school, the excessive flooding in the rainy season makes the school area difficult to be accessed. So, we need support from the government,

Similarly, 22.25% of respondents indicated that it also increased time spent on extra jobs by members of communities while 9% claimed the same for their households. Likewise, 14.75% of the respondents mentioned an increase in strife, petty jealousy, and conflict as one of the implications of climate variability and change in their communities while 6.25% of the respondents affirmed the same for their households.

In the same vein, insignificant percentages (1.25% for the households and 0.75% for the communities) of respondents confirmed that there was more attention by the government and NGOs because of changing climate impacts. Also, 7.75% of the respondents submitted that changing climate has led to fewer family gatherings as time was spent fending for food in their communities while 4.35% stated the same for their households. Participants who were from the marginal areas, especially the fisher folks, acknowledged the support of the NGO during festivities. They affirmed that some NGOs visit their communities with palliatives and at times conducted medical outreaches in their communities.

Likewise, 43.25% of the respondents claimed that changing climate has led to a loss of family ties due to outmigration in their communities while 17.5% claimed the same for their households. Similarly, 31.75% of the respondents affirmed that changing climate has led to higher levels of crime associated with their communities, and 19.25% of the respondents stated the same for their individual households. During the focus group discussions, an elderly man said:

There are tremendous impacts of changing climate on the residents of Lagos. When people go to get fish from the lagoon, they sometimes do not see or get enough to take care of their families. It makes them not have money to spend. Some of them (mostly youth) get involved in crime as alternatives.

Similarly, 26.25% of the respondents claimed that their households were experiencing hunger-related diseases due to changing climate and its variability while 12.5% stated the same for their households. Equally, 36% of the respondents affirmed that changing climate caused their communities to experience water-related diseases while 15.25% claimed the same for their households. Correspondingly, 41.25% claimed that changing climate has led to children not attending schools in their communities while 13.25% affirmed the same for their households. A participant in the focus group discussion in Bariga said:

We witnessed flooding in our community mostly during excessive rainfall that we have been witnessing because of changing climate. This increases the health issues in our communities since there is no piped water. The wells are contaminated. Sometimes our children may not attend school because of the danger of the floods

This statement echoed Howard et al.'s (2015) assertion earlier that excessive flood in the city was connected to diseases and health issues in communities because of inadequate sanitation facilities. The results also indicated that very negligible percentages of respondents (0.75% in the communities and 0.5% in their households) affirmed that there were more social gatherings to discuss issues of climate variability and change. Furthermore, some of the fishmongers in the focus group discussions linked the effects of excessive flooding attributed to changing climate to their livelihood insecurity. One of the elderly fishmongers that participated in the focus group discussions said:

The government is not always thinking of us, they do not consider our livelihood, and they refuse to accept that our livelihood is tied to our residence. We are born in water, we live in water, and our life is all about water. Fish that provides our livelihoods is from water. They are only used to destroying our houses thinking that we are primitive not knowing that it is connected to our livelihoods.

Another participant that was a fishmonger in the focus group discussion said:

Changing climate has promoted flooding in diverse places which has negatively impacted our economy. This has affected fish catch. Thereby our members are changing to other vocations.

The decline in fish catch as a result of changing climate supported in the literature of Weiskopf et al. (2020), Adewale et al. (2017), Omitoyin and Tosan (2012) and OECD (2014) may invariably result in a decrease in financial capital or empowerment of fishmongers and could affect the fulfilment of necessary societal obligations such as their children school attendance as highlighted by the participants in the survey. Generally, summing up the results echo the findings of Reckien et al. (2017) and Satterthwaite et al. (2018; 2020) that suggest that the households' and communities' socio-economic parameters in urban societies are impacted by changing climate and its variability. In addition, Matsumoto (2019) supports this assertion by affirming that changing climate influences the socio-economic system through its responses to the natural system. Hence, the impacts of climate variability and change in households and communities, in general, could have debilitating effects on societal parameters. The above results of changing climate impacts on socio-economic of their household and community also resonate with Ekoh et al. (2023), Reckien et al. (2018) and Steele et al. (2012) who state that changing climate issues may need to be equated with justice and equity concerns in cities since vulnerable residents in marginal communities are more affected by its impacts than other city dwellers.

5.8 ADAPTATIONS AND COPING ABILITIES ENGAGED BY THE HOUSEHOLDS AND COMMUNITIES IN LAGOS MEGA-CITY TO THE IMPACTS OF CLIMATE VARIABILITY AND CHANGE

The continuous impacts of climate variability and change on urban households and communities need veritable adaptation strategies alongside residents coping abilities for their sustainable living. However, there is a growing challenge to adapting to changing climate in communities around the world at present to both current and expected impacts (Wannewitz & Garschagen, 2023). There are adaptation gaps in different localities in both advanced and developing economy countries,

making communities, firms, and individuals (households) to always reconsider their adaptation procedures for the present and the future (Bellon & Massetti, 2022). Hence, the study assessed the adaptation and coping abilities that the Lagos Mega-city households and communities engaged in to cope with the impacts of changing climate.

5.8.1 Household and community responses to climate variability and change impacts

The importance of household and community adaptation procedures against the growing impacts of climate variability and change cannot be overemphasised. This is because adaptation to changing climate cannot be achieved through only household adopted strategies alone but will need to be strengthened through the community. Wannewitz and Garschagen (2023) surmise that adaptation is relatively communally bounded together because of infrastructure, resource management and geography. The results in Table 5.26 below depict how the household and community, in general, respond to climate variability and change. Chi-Square tests were undertaken to examine whether there was an association between selected socio-demographic variables (gender, age, education level and household structure/ materials) and household and community responses to climate variability and change impacts. No significant differences were discerned for any of the impacts.

Table 5.26: Household and community responses to climate variability and change impacts (n=400) – affirmative responses only

Responses	Household		Community	
	Frequency	% of respondents	Frequency	% of respondents
Participating more in seasonal on farm-activities as a livelihood diversification strategy	2	0.5	5	1.35
Participating more in off-farm activities (e.g., small businesses and trade) as a livelihood diversification strategy	115	28.7	300	75
More reliance on natural resources for food	35	8.75	44	11
Begging	12	3	47	11.75
Less fishing	18	4.5	87	21.75
Crop diversification	1	0.25	4	1
Use of more climate-resilient crops and animal varieties	1	0.25	2	0.5
Changing cropping calendar and pattern	3	0.75	4	1
Changes in fishing practices	55	13.75	173	43
Adopting water conservation measures	-	-	1	0.25
Working/ farming in cooperatives	-	-	1	0.25
Working for clothes and food	49	12.25	82	20.5
Relocating some or all household members/ outmigration	24	6	71	19.25
Relying on donations or grants from NGOs	-	-	10	2.5
Relying on donations or grants from the government	-	-	1	0.25

Three-quarters (75%) of the respondents affirmed that the communities were participating more in off-farm activities such as small businesses and trade as livelihood diversification strategies against changing climate impacts while 28.75% of the respondents stated the same for their households. Ho, Tsusaka, Kuwornu, Datta and Nguyen (2022) and Ahmad, Yassen and Saqib (2022) show that the threat of climate variability and change may induce livelihood diversification

strategies among the people. Close to a third of the respondents (32.25%) of the respondents claimed that working for clothes and food is a response to changing climate impacts in their communities while 16.5% said the same for their households. However, 11% of the respondents affirmed that the communities were more reliant on natural resources for food while 8.75% of the respondents declared the same for their households as a response to changing climate impacts.

Similarly, 21.75% of the respondents affirmed that due to the implications of changing climate impacts, they now carried out less fishing in their communities while 4.5% admitted the same for their households. Alam and Mallick (2021) affirm that the small-scale artisanal fisherfolks in coastal areas are susceptible to changing climate and its variability with implications on their livelihoods and community life. Also, Opele, Afolashade, Oresanya and Aderinto (2022) show that the effects of changing climate on fishmongers' livelihoods in Lagos are more than that experienced in the other parts of the southwest coast of Nigeria.

Likewise, 20.25% of the respondents claimed that working in cooperatives by members of communities and 12.25% for households were a response to the implications of climate variability and change. Also, 19.25% of the respondents stated that relocating some of/all household members or outmigration was a response to the implications of climate variability and change in their communities while 6% affirmed the same for their households. Similarly, 11.75% of the respondents stated that some household membership has resulted in begging as a response to the implications of climate variability and change in the city in their communities while 3% of the respondents stated the same for their households.

Only 2.5% of the respondents claimed that some communities were relying on donations or grants from NGOs as a response to climate variability and change. Similarly, a negligible percentage of the respondents (0.25%) were relying on donations or grants from the government and while none relied on donations from the private sector. Also, 43% affirmed that there have been changes in fishing practices in their communities while 13.75% of the respondents stated the same for their households. Similarly, a negligible number of respondents (1% for communities and 0.5% for their households) identified crop diversification as a response to changing climate and its variability. Likewise, the use of more climate-resilient and animal varieties (only 0.5% for communities and 0.25% for households) and also changing cropping calendar and pattern (0.75% for communities

and 1% for households) had also negligible responses among the respondents. Only one respondent affirmed that the adoption of water conservation measures was a response to climate variability and change for their households and communities. There was no response for investment in irrigation.

There is evidence in the literature that households' and communities' responses are indispensable towards the development of mitigation, adaptation and coping techniques that are expected to tackle and reduce and ameliorate the negative implications of the impacts of climate variability and change in every society (Elias, 2018). In addition, when society examines and responds to the negative effects of climate variability and change through the building of the capacity to adapt and cope with specific impacts, the primary vulnerability of the population may be reduced (Watts et al., 2015). Furthermore, in a bid to cope with changing climate impacts, literature continued to echo that the adaptation techniques that may be developed alongside its response and acceptance in the households and communities depend on adequate information on changing climate impacts and the socio-economic characteristics of its immediate environment (Elias, 2018). Likewise, Diem et al. (2021), Kaczan and Orgill-meyer (2019), Kapoor (2019) and Yang (2021) emphasise the indispensability of building individual capacity, availabilities of credits, social networking and change in livelihood strategies as essential response that will encourage reduction, recovery and increase in coping abilities from shock or vulnerability.

5.8.2 Challenges faced by households and communities in adopting climate variability and change adaptation strategies

The study assessed the challenges faced by households and communities in adopting climate variability and change adaptation strategies through face-to-face interviews and focus group discussions. Table 5.27 below depicts the challenges faced in the household and/ or community generally to adopt climate variability and change adaptation. Chi-Square tests were undertaken to examine whether there was an association between selected socio-demographic variables (gender, age, education level and household structure/ materials) and the challenges faced in the household or community generally to adopt climate variability and change adaptation. No significant differences were found.

Table 5.27: The challenges faced in the household or community generally to adopt climate variability and change adaptation (multiple responses) (n=400)

Challenges	Household		Community	
	Frequency	% of respondents	Frequency	% of respondents
Lack of knowledge and information	365	91.25	367	96.75
Insufficient training	128	32	15	3.25
Lack of capital/ funding/ money	53	13.25	91	22.75
Labour shortage	2	0.5	10	2.5
Lack of institutional support	69	17.25	147	37.5
Lack of alternative sources of energy	25	6.25	54	13.5
Lack of markets	8	2	16	
Transportation challenges	48	12	71	17.75
Corruption and poor governance	124	31	196	49

The study revealed that the majority of the respondents (91.25%) acknowledged lack of knowledge and information as one of the challenges faced in adopting climate variability and change adaptation strategies in city households while the majority (96.75%) claimed the same for their communities. Likewise, 15% affirmed that insufficient training was a challenge faced by the city households in adopting climate variability adaptation strategies while 32% identified the same for their communities. Evidence in the literature like Whitmarsh and Capstick (2018), Eakin (2022) and Douglas (2017) has shown the indispensability of understanding, knowledge and training in response to environmentally sustainable practices that will encourage adaptability to the impacts of changing climate. Thus, processes that will increase knowledge and understanding need to be sustained in the Mega-city.

Similarly, 13.25% affirmed that lack of capital or funding or money were challenges faced by the city households in adopting climate variability and change climate variability and change adaptation strategies while 22.75% identified the same for their communities. Also, 17.25% indicated that the absence of institutional support was one of the challenges faced in the city

households in adopting climate variability and change adaptation strategies while 36.75% affirmed the same for their communities. Ding et al. (2018), Kapoor (2019) and Ndhlovu (2018) highlighted that financial capital is a promoter of livelihood adaptive strategies for vulnerable individuals and communities.

Equally, 31% indicated corruption and poor governance as part of the challenges faced in the city households in adopting climate variability and change adaptation strategies include while 49% admitted the same for their communities. Likewise, 12% inferred transportation as a challenge faced in the city households in adopting climate variability and change climate variability while 17.75% affirmed the same for their communities. Also, 6.25% of the respondents indicated that lack of alternative sources of energy was part of the challenges faced in the city households in adopting climate variability and change climate variability and change adaptation strategies while 13.5% inferred the same for their communities.

Similarly, 2% of the respondents affirmed the absence of markets as a challenge faced by city households in adopting climate variability and change climate variability and change adaptation strategies while 4% indicated the same for their communities. Also, 0.5% inferred that the shortage of labour was a challenge faced by the city households in adopting climate variability and change adaptation strategies include while 2.5% claimed the same for their communities. However, 1% of the respondents did not identify a single response as a challenge faced in the city households in adopting climate variability and change adaptation strategies while 1.25% could not recognise a single response for their communities.

5.8.3 Forum to discuss the impacts of climate variability and change in the communities of Lagos Mega-city

The study assessed whether there were opportunities/ forums to discuss climate variability and change impacts in the community. Subsequently, 29% of the respondents indicated that the forums to discuss the impacts of climate variability and change in their communities were available, while 27.5% inferred that they were not available, and 43.5% said they did not know of any forum that

was convened to discuss the implications of changing climate. This is represented in Figure 5.9 below.

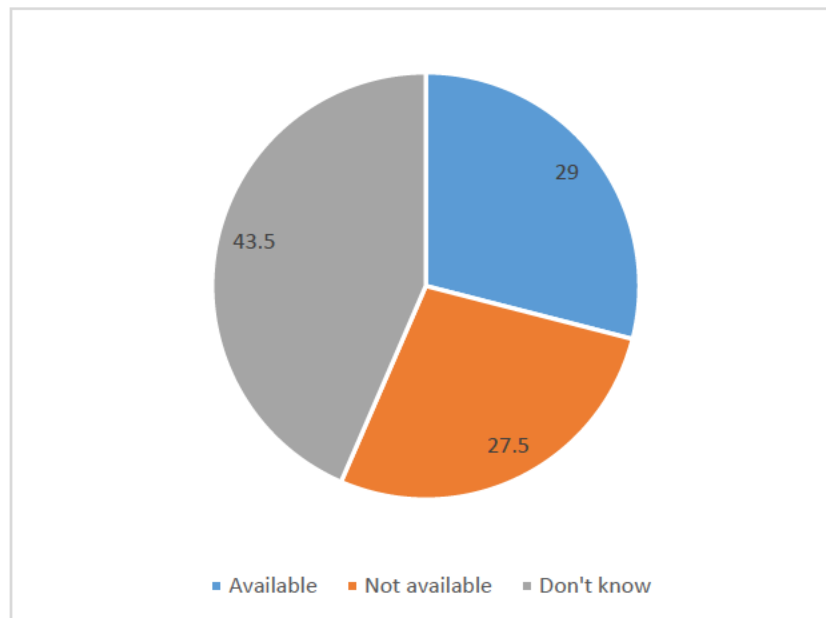


Figure 5.9: Forum to discuss climate variability and change in Lagos Mega-city (n=400, in %)

The study also identified from the respondents the convener of the forum for these discussions in their communities in the city. Consequently, 29.25% of the respondents identified community members as the organisers of the programme. Only one respondent identified NGOs as the convener of the forum while 70.5% have no idea about the forum. This is represented in Figure 5.10 below.

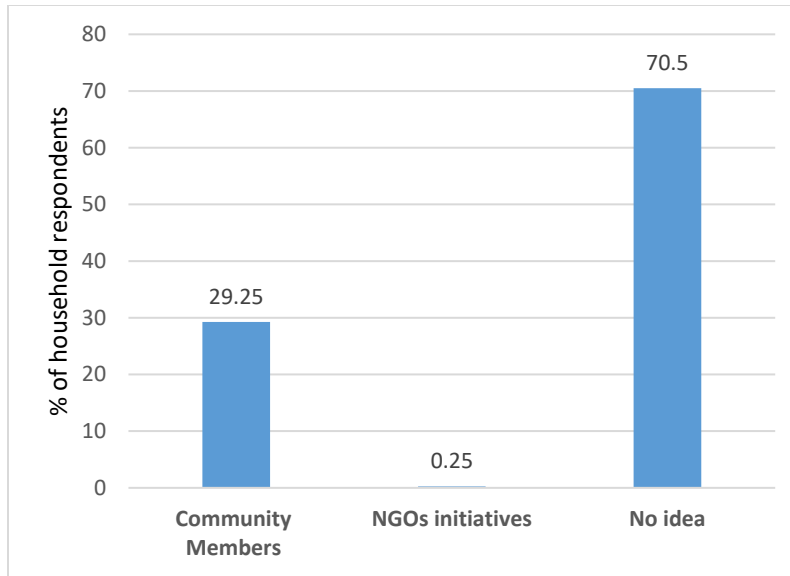


Figure 5.10: Organisers of the forum for discussions of climate variability (n=400, in %)

In the focus group discussions, the participants also acknowledged that community members form associations to tackle the effects of changing climate. One of the participants said:

Residents have no help from the government to cope with changing climate, but they formed local associations and cooperatives. They always use sand to fill up places where erosion washed away the sands.

Another participant in the focus group discussions said the following concerning the contributions of their community and the absence of government assistance to minimising the negative impacts of climate variability and change in their community:

The government has not been assisting the communities on the issue of changing climate. Trees are supposed to assist in minimising the effects of erosion, no one or the government is putting back the lost trees. It is only the community associations that do the sand filling of the places whose sands have been taken away. However, these community and people approaches are limited because of funds.

5.8.4 The levels of contributions and participation of household members in the climate variability and change impacts discussions forum assessed in the study

The levels of contributions and participation of household members in the climate variability and change impact discussion forum were assessed in the study. It was found that 15.5% of the respondents were not participating in the changing climate forums while 14% of the respondents affirmed that they have attended the meetings. In the same vein, 8% of the respondents indicated that they were always involved in mobilising participants for the meetings while 9% claimed they were always sharing their concerns in the meetings. Also, 8% of the respondents inferred that they were part of the decision-making teams in the respective meetings while 6% were participating in climate variability adaptation projects that were engaged by their communities. Similarly, 4.75% of the respondents declared that they played leadership roles in their respective forums. Table 5.28 below depicts the contributions and delineation of household members in climate variability and change discussions forum in the study area.

Table 5.28: The contributions and delineation of households in climate variability and change impact discussion forum in Lagos Mega-city (multiple responses) (n=400)

Participation and contributions	Frequency	% of respondents
Do not participate	62	15.5
Attending meetings	56	14
Mobilising participants for meetings	32	8
Sharing their concerns in these meetings	36	9
Making decisions in the meetings	32	8
Participating in climate variability adaptation projects	26	6.5
Leadership roles	19	4.75

5.8.5 Projects initiated to assist the communities in Lagos Mega-city to adapt/ respond to climate variability and change impacts

The study examined the types of projects that were initiated by the communities in the city to encourage adaptation to climate variability and change impacts. Among the surveyed household respondents, 10.25% were not aware that projects were initiated in their communities to encourage adaptation to climate variability and change impacts. In addition, 71.7% of the respondents claimed that there were no projects initiated in their communities to assist them to adapt to climate

variability and change impacts. However, only 7% of the respondents affirmed the knowledge of the initiatives of the NGOs school project and floating homes prepared to assist the communities that were virtually sitting on the lagoon in the city to adapt to climate variability and change impacts. Two respondents identified the government projects of the health centres as an activity prepared to encourage adaptation to climate variability and change impacts. Similarly, 1.25% identified the construction of roads and culverts by the government to assist communities on the coast of the lagoon to adapt to climate variability and change impacts. Also, 1.25% of the respondents (mostly those living around the lagoons) affirmed the provisions of palliatives by the NGOs to mostly the fisherfolks residing by the lagoons.

Some of the participants in the focus group discussions concurred with the views of the household respondents on the governmental support in road construction, the building of culverts and planting of health infrastructure/ centres in their locality as adaptation strategies to support the people against the impacts of changing climate. They also pinpointed some of the projects that were sponsored and engaged by their communities against the impacts of climate variability and change.

The projects include:

- Construction of pedestrian walkways during flooding
- Sand filling of the flooded environment using sandbags
- Construction of drainage systems by the communities
- Spiritual activities to lessen rainfall
- Construction of high walls to prevent impacts of flood

One of the participants of the focus group discussion concerning mitigation and adaptation procedure said:

I am an Egun man. We always prepare sacrifices for the gods that can rectify the change we are experiencing. We also construct wooden walking pedestrian bridges, especially during the rainy seasons so that our people can use them as a walkway when our community is flooded. This is done through the community association where we all have to contribute. So many houses that are faced with flooding, make defence walls to protect them from floods.

Evidence in literature such as Kassa (2019), Kaczan and Orgill-Meyer (2019), GPR2C (2016) and Diem et al. (2021) has shown that social networks and associations such as NGOs, religious groups, community-based organisations etc. are social capital that supports the building of resilience and enhancement of coping abilities against shocks. Furthermore, some of the participants in the focus group discussions acknowledged the following projects that were initiated and supported by the state government against the impacts of changing climate in their communities:

- Public awareness programmes on government-owned radio and television stations
- Channelisation of the area

A senior member of the Lagos State Ministry of Environment and Water Resources reiterated in line with the discussion in the focus group discussion on governmental contributions against changing climate impacts in the city. He stated that:

The government through the Ministry of the Environment and Water Resources educates the people on changing climate. When the temperature is high, the government does public announcements in the media encouraging the people to drink water to avoid calamity and cope with dehydration.

Another key informant (a senior member of the Ministry of Environment and Water Resources) highlighting that the government encourages adaptation and coping procedures in the city to changing climate said:

The government of the state supports adaptation and coping procedures against changing climate by regularly constructing canals and drainage systems where it is needed, cleaning existing drainage channels and systems for easy flow of water before the rainy seasons, sensitise the people, encouraging the planting of special trees (supplied by the government). Sea walls (high walls) have been constructed on the Bar Beach end of the Atlantic Ocean to prevent flooding in Lagos Island and the government enforces building codes and guidelines with regular demolishing of structures on drainage lines.

The adaptive procedures and resilience building as seen from the project initiated by diverse stakeholders including the public/ community against changing climate impacts may be regarded as progressive since all stakeholders' hands are on the desk. This is in line with the assertion in literature as shown by Dandy et al. (2019), Broto et al. (2015) and Eakin et al. (2022) that collective power building is essential in the identification of favourable adaptation strategies to negative impacts of changing climate when the residents and the public have an understanding of the knowledge of the harms, risks and values in their society.

5.9 CONCLUSION

In this chapter, data collated from household respondents, focus group discussions participants, key informants and observations during field visits to the study area are presented, analysed and discussed in cognisance of the research themes. Hence, the analysis and discussions are buttressed with up-to-date scientific knowledge from pieces of literature and policy documents to provoke a better understanding of the research and its binding concepts, engendering a workable conclusion and recommendations that will support the sustainable management of the city and the other developing economy countries cities in the face of the continuous impact of the imminent changing climate and climate variability. The chapter further reveals and describes the city's increasingly defective nature which includes structural, socio-economic and livelihood components that were encouraged by the adverse implications of changing climate and its variability which hinders its climate security and at ends upsetting its urban environmental security.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 INTRODUCTION

The impacts of changing climate on the human population and its environment are becoming noticeable in different parts of the globe. Hence, the urban environment being the largest known concentration of human population in different parts of the world is predisposed to these probable impacts of changing climate and will need to be subjected to adequate mitigation and adaptation procedures for its societal sustainability (Abbass, Qasim, Song, Murshed, Mahmood & Younis, 2022; Farrell, 2018; Goodwin, Olazabal, Castro & Pascual, 2023; IPCC, 2018; Satterthwaite et al., 2018). Subsequently, the knowledge and understanding of the process of changing climate alongside its impacts on man and its environment by the residents of every community are indispensable in the development of the amelioration, mitigation, and adaptation procedures that will be engaged in every society in this changing climate era (Adeleke & Luetz, 2023; Adusu, Anafo, Abugre & Addaney, 2023; Fila, Funfgeld & Dahlmann, 2023).

In this vein, the study through literature analysis and surveys conducted on household participants and diverse stakeholders in the Lagos Mega-city examined the implications of climate variability and change on its urban environmental security. It identified through the perceptions of the household's participants and other stakeholders, the nature and extent of climate variability and change in the city. It also determined the impacts of climate variability and change on urban environmental security, biodiversity with emphasis on aquatic livestock, households' livelihoods, and well-being of the city. It further examined the adaptation capacity and measures engaged by the city residents to changing climate. This chapter summarises the results that were obtained during the research and provides recommendations and conclusions on the study.

6.2 SUMMARY OF THE RESULTS AND DISCUSSIONS

The key results and discussions that were presented for the study in relation to its aims and objectives are summarised in this section. This is done with a prime focus on the overall objectives of the study which was to evaluate the implications of climate variability and change on urban environmental security, using Lagos Mega-city as a case study.

6.2.1 Extent and the nature of climate variability and change impacts on urban environmental security of Lagos environmental security in Lagos Mega-city

This objective was to identify the extent and nature of climate variability and change through the perceptions of the household respondents, the focus group discussion participants, and the selected key stakeholders on urban environmental security in Lagos Mega-city. As a prelude to the determination of the extent and nature of climate variability and change, the study assessed the levels of awareness of climate variability and change in the city. It showed that there was widespread awareness of the issues concerning climate variability and change in Lagos Mega-city. The result is dissimilar from the analysis of the Gallup study by Lee et al. (2015) when the majority of the persons assessed in the developed world were aware of changing climate and the majority surveyed in the developing world did not hear or were not aware of the changing climate concept. However, the study may infer that the increasing levels of awareness in Lagos Mega-city may not be unconnected with the perceptions of the features, the extent, and the nature of the negative impacts associated with changing climate being experienced in their communities. This is in line with Elias (2018), Whitmarsh and Capstick (2018) and Whitmarsh et al.'s (2022) research that extreme weather events and risk exposure may increase public perception of changing climate.

It was also found that the majority of the respondents did not have a sufficient understanding and knowledge of the extent or degree of contributions of the socio-community features such as air pollution, water pollution, land pollution, use and burning of fossil fuels, ozone depletion, etc. to climate variability and change. For example, more than half of the household respondents interviewed did not know the extent of the contributions of air pollution to climate variability and change. Likewise, the majority of the household respondents interviewed did not know the extent

of contributions of land and water pollution; use and burning of fossil fuels, clearing of trees, loss of wildlife; and use of pesticides and herbicides to changing climate. Similarly, three-quarters of the respondents did not know the extent of the contributions of ozone layer depletion to climate variability and change.

This indicates that there was less knowledge about what may contribute to the phenomenon of changing climate and its variability. Sun, Zhang, Ding, Chen, Qin and Zhan (2022) and Clarke, Otto, Stuart-Smith and Harrington (2022) note the contributions of humans to changing climate and emphasised the importance of understanding and knowledge of this influence in the development of mitigation and adaptation approaches to the impacts. Therefore, the knowledge and understanding of what contributes to the phenomenon of changing climate and its variability are strongly essential for the societal acceptance of the procedures that may be prescribed for its amelioration, mitigation and adaptation and will be essential in supporting policy formulation and programmes that are imperative in the process of the achieving climate security in the city.

Furthermore, it was established that most of the interview respondents perceived that in the recent (0 to 5) years, there were increases in the intensity of rainfall, temperature and also a longer annual rainfall season in the city when compared to 5 years and above. Likewise, more than half of the respondents affirmed that there were increases in UHI in their communities in the recent (0 to 5) years when compared to 5 years and above. Guo et al. (2022) note that there has been increasing urban land surface temperature in fast-growing cities influenced by urbanisation, changing climate and interannual climate fluctuation and in Lagos Mega-city day time land surface rise up in most afternoons and most after midnight for the past 20 years.

In addition, the majority of the participants in the focus group discussions affirmed that climate variability and change had effects on the amount and timing of rainfall in their communities. Evidence from Adegun (2023), Ekoh and Teron (2022) and Ekoh, Teron, Ajibade and Kristiansen (2022) affirm the extreme and high rainfall nature of Lagos Mega-city. Moreover, most of the respondents in the household interviewed confirmed that there were increased changes in the intensity and frequency of flooding in their communities while participants in the focus group discussions emphasised that climate variability and change create climate extremes which include excessive floods during the wet season. Atufu and Holt (2018), Enoh et al. (2022; 2023) and Israel

(2017) surmise that flooding events linked to climate variability and change occur more frequently in the city. Similarly, about half of the household respondents acknowledged that there was increasing coastal erosion in the city which was also corroborated by the participants in the focus group discussion. Consequently, the study reveals that the environmental integrity of the city was being affected by changing climate alongside its variability through recurring extreme events with low adaptive and coping abilities. This may invariably distort the city's environmental integrity with adverse effects on its urban environmental security. The findings are in agreement with Boretti and Rosa (2019), Eekhout et al. (2018), Granberg and Glover (2021), IPCC (2022) and Mbow et al. (2019) supporting the connection of extreme events to changing climate with negative effects on environmental integrity which is key to urban environmental security.

6.2.2 Implications of climate variability and change in biodiversity (especially aquatic livestock) depletion on urban environmental security of Lagos Mega-city

This objective was to determine the implications of climate variability and change in biodiversity depletion on the urban environmental security of Lagos Mega-city with a focus on aquatic livestock. Consequently, the study showed through the perception of the majority of household respondents that sourced aquatic species and the participants of the focus group discussions that the rate of the quantity of the aquatic species and ocean species sourced in their households for the past 5 or more years has reduced greatly. Participants in the focus group discussions attributed the cause of the loss in aquatic biodiversity (biodiversity depletion) to habitat destabilisation/ destruction, sand mining/ dredging, water pollution, and the presence of invasive species, especially water hyacinths as well as changing climate. For instance, they claimed a fish species called snappers in recent times had become difficult to catch while the levels of shrimp caught had also reduced in the Lagos lagoon. The results echo the findings of Mahli et al. (2020) and Weiskopf (2020) where biodiversity depletion (loss of biodiversity) is suggested as a result of changing climate and its variability. Talukder et al. (2022) in their research on climate change ocean biodiversity loss surmise that a decline in fish diversity in oceans because of distortions in food webs caused by changing climate will increase the price of fish resulting in adverse impacts on human livelihoods. Also, Pecl et al. (2017) and Fakoya et al. (2022) surmise the loss of

biodiversity may have impacts on the livelihoods, well-being, and food security of the city. This is because human livelihood and well-being mostly depend on the nature of ecosystem functions and supplies for their livelihood (NAS/ TRS, 2019). In addition, Xiao, Wu, Guo and Tao (2020) affirm that biodiversity conservation is essential for the sustainability of life. Hence, maintenance of city environmental integrity is a veritable key to sustainable urban environmental security which is indispensable for biodiversity stability.

6.2.3 Implications of climate variability and change on households' livelihoods and well-being in Lagos Mega-city

This objective was to determine the implications of climate variability and change on households' livelihood and well-being in Lagos Mega-city in Nigeria. As a prelude to the determination of the implications of climate variability and change on households' livelihood and well-being in the city, demographic, socio-economic, and socio-livelihood parameters of the study area were assessed. Dang et al. (2020), Feinstein and Mach (2019), Haider (2019), Isuku and Nwafor (2019), Madu (2016) and UNDP (2013b) affirm that changing climate impact and adaptation responses and capacity depend on the level of information, education, asset and income of the people. The study showed that the majority of the household respondents had formal education training which is a product of a free and compulsory primary education policy that was embraced since the 1950s in some parts of Nigeria and the city. Though, the study noted that there have been threats to the sustenance of the formal education training for school pupils specifically in the communities that reside on and in proximity to the lagoons (having floating homes) and other areas prone to water security challenges such as excessive flooding which hindered students from attending schools regularly. Also, the occupations of the household respondents were found to be diverse. Trading and business were key forms of occupation for the respondents. Only one hundredth of the respondents were in the government sector and around a tenth of the respondents were unemployed.

Unemployment was one of the issues highlighted by the majority of the fishmongers in the focus group discussions as a strong implication of changing climate in the city, linking the consequences of the impacts of changing climate to their livelihood insecurity. Campbell (2022) notes that

changing climate is an additional urbanisation driver that compounds or increases the existing urban threats to socio-economic parameters such as poverty, crime, unemployment and out-migration. Likewise, more than half of the household respondents claimed that changing climate has led to increasing job searching of members of their communities while close to one-fifth of the respondents affirmed the same for their household. Furthermore, about one-fifth of the household respondents claimed that the impact of changing climate has contributed to increasing levels of crime in their communities. This was corroborated by some of the fishmonger participants in the focus group discussions who claimed some of their youths sometimes resulted in crime when they were affected. The study also identified through the perceptions of the participants in the household face-to-face interviews, focus group discussions, and key informant interviews that climate variability and change were having negative implications on the socio-economic parameters of the populace. Similarly, about half of the represented households in the survey were earning below 200 dollars as household income per month. Therefore, they were earning below the poverty line. Subsequently, since most of the households' respondents indicated that there had not been contributions from the government through monetary or financial means to their households except through the provision of free school education to their households (a tenth of the respondents specified), then capacity expected against their vulnerability may be limited. This is because household income is a prime factor of the financial capital that is indispensable in improving other capitals and will enhance the capacity to support livelihood strategies that will encourage adaptation to climate variability and change impacts (Lax & Krug, 2013; Wei et al., 2016). The results when compared with studies in the literature are similar to that of Thomas et al. (2019), Olsen (2009), Reckien et al. (2017), GPR2C (2016), Lawanson (2016) and Adama (2020) which affirm that climate variability and change have negative implications on urban residents, especially the livelihoods and well-being of poor people.

It was further revealed that more than 90% of the household respondents were residing in formal structures while less than 10% were living in informal structures or shacks which were mainly houses in Maroko in the Mainland LGA and Ilaje community in the Somolu LGA. Additionally, most of the household respondents acknowledged the use of electricity to power their houses and paraffin to power their cooking stoves and lanterns during power outages. However, physical assets like the availability of sustainable portable water are not available for all. Only a few houses in the city were connected to the public water supply. However, Day et al. (2016), Ogwumike and

Ozughalu (2016), Pandey et al. (2017), Siksnyte-Butkiene et al. (2021) and Sovacool and Drupady (2016) emphasise that inadequate basic services and infrastructure worsen individuals and communities capabilities to cope with changing climate impacts and vulnerability.

In addition, the study revealed that the majority of the city dwellers did not depend on natural resources for their livelihoods. This result resonates with the findings of Gupta and Jadon (2019), Mohamad, Hj Ayob and La (2013) and Wahab, Odunsi and Ajiboye (2012) that increasing modernity, technology, and city lifestyles are far changing cities through their diffusion of traditional practices and cultural heritage. Hence, the study found that about four-fifths of the respondents were not depending on natural resources for their livelihoods. Although ocean, animals, aquatic livestock, and lagoons still played vital roles in enhancing the livelihoods of less than one-fifth of the respondents while freshwater and garden materials were negligibly used, and forestry and minerals were not utilised by any of the respondents for their livelihoods. These natural capitals in the city when properly annexed could generate productive and financial assets that will improve other capitals, enhancing the coping abilities of the residents against the imminent changing climate impacts. However, it was revealed in the study that only a negligible percentage of the household respondents were involved in cropping which was one of the main traditional occupations of the initial residents of the city. The study also indicated that about one-fifth of the households surveyed kept livestock in the past five years. It was further revealed that the majority of the households surveyed that kept chickens/ guinea fowls, sheep, rams and goats indicated that the number had greatly decreased through the years.

6.2.4 Adaptation and coping abilities of the households and communities generally in Lagos Mega-city to the impacts of climate variability and change

The study identified the adaptation strategies and coping abilities of the households and communities generally in Lagos Mega-city to the impacts of climate variability and change. This is because the strategy for individual and community adaptation measures and coping abilities to vulnerability, shocks and changing climate impacts is indispensable for the sustenance of the city's environmental integrity and in the end its urban environmental security (Pandey et al., 2017; Mariño & Rozenblat, 2022; United Nations, 2016a; UNDP, 2013b & Satterthwaite et al., 2020). It

identified through the perceptions of the household respondents the livelihood diversification strategy employed against changing climate impacts in the city. It was revealed that the majority of the respondents in the household survey were participating more in off-farm activities such as small businesses and trade as a livelihood diversification strategy against changing climate impacts. Other livelihood diversification strategies identified by some of the respondents included working for clothes and food, relying more on natural resources for food, working in cooperatives by members of the households, carrying out less fishing, changes in fishing practices, relocating some of/all household members or outmigration. A negligible percentage of respondents identified begging, relying on donations or grants from NGOs, crop diversification, the use of more climate-resilient and animal varieties, changing the cropping calendar alongside patterns, and adoption of water conservation measures as livelihood diversification strategies engaged against changing climate impacts. However, there was no single response for investment in irrigation.

The majority of the household respondents indicated that no projects were initiated in their communities to assist and encourage them to adapt to the impact of climate variability and change variability and change. A negligible number of respondents identified the initiation and provision of health centres, construction of roads and curvets by the governments and less than a tenth of the total respondents affirmed the initiation of school projects, floating homes and provisions of palliatives by the NGOs as ways to assist the residents in adapting to climate variability and change. However, the construction of pedestrian walkways during flooding, sand filling of the flooded environment using sandbags, construction of drainage systems, construction of high walls to prevent impacts of flood, and engagement of spiritualists to lessen the frequency of rainfalls were the adaptation strategies initiated by different communities in the city.

Lack of knowledge and information was indicated by most of the household respondents as challenges faced by households and communities in adopting climate variability and change adaptation strategies in the city. While other challenges such as insufficient training, corruption, poor governance, lack of alternative sources of energy, absence of markets, lack of capital or funding, and absence of institutional support were identified by less than one-fourth of the respondents. Furthermore, it was realised that just a little above a quarter of the respondents were participating in the community forum where impacts of climate variability and change were

discussed while about a quarter claimed such were not in existence and the remaining others said they were not aware of it.

6.2.5 Policy and programme recommendations based on research findings

The study realised the need for a policy thrust that will enhance climate security through the process of urban environmental security and SULF. Hence, the study highlights and recommends sustainable policy approaches that will encourage urban environmental security. This is further discussed under recommendations.

6.3 REFLECTION ON THE THEORETICAL FRAMEWORK ENGAGED IN THE STUDY

The study focused on the assessment of urban climate security through the guidance of the political ecology concepts of urban environmental security and sustainable urban livelihood. The political ecology theories and concepts were developed around the mid-twentieth century to encourage and enhance societal sustainability. The philosophies and analysis of the political ecology theories are based on the relationship between nature and society with the perception that ecological change will only be understood through the consideration of the economic and political systems within its embedded institutions (Benjaminsen & Svarstad, 2018; Tetreault, 2017). They are interdisciplinary principles of socio-political-economic development shielded with environmental concerns. Therefore, they are a veritable process in the assessment of environmental concerns in relation to the socio-political parameters of the communities. Hence, they enhance holistic and integrative approaches to the environmental survey.

Utilising these theories for the Lagos Mega-city assessment allowed for an in-depth understanding and analysis of the implications of climate variability and change through the considerations of its socio-economic and socio-demographic features alongside the parameters that distort human livelihoods and its environment. This was intended to identify, delineate and suggest appropriate strategies that will enhance mitigation and adaptation procedures to the impacts of changing

climate and climate variability in the city. This was designed with the ultimate goal of achieving environmental sustainability and encouraging climate security in the city.

Consequently, the frameworks examined and analysed the Lagos Mega-city in relation to the well-being of its residents and the city structure to provide a concrete and enduring proposition that will support its environmental and socio-economic sustainability. This was done with the perspective that the well-being of every urban community and city is dependent on its livelihoods since adequate and supportive livelihoods encourage its urban climate security.

Subsequently, the study indicated through the survey conducted on the household respondents in the city that trading (not of agricultural products) and private business (which include organised private sector business) were the main livelihoods and income sources in Lagos Mega-city. It identified that there has been a drastic reduction in the city's dependence on natural sources of livelihood that were available for the dwellers such as the ocean, lagoons, aquatic livestock, animals and freshwaters because of lifestyle change due to urbanisation, increasing modernity, commoditised nature, and technology. In addition, a drawback was that land for agricultural activities has become a challenge and city dwellers prefer using land for other purposes and the continuous decrease and depletion of aquatic biodiversity. This invariably contributed to the reduction of dwellers' engagement in the utilisation of natural resources for their livelihoods.

This study contributes to the understanding of the interaction of human environment, society and governance in the process of achieving sustainable development. Thus, it identifies the implications of climate variability and change and rapid urbanisation on human and urban society. It enlivens the unsustainable management of urban society in a changing climate era which needs focus and utmost attention by society and the government in mostly growing cities in developing economy countries. It underscores the importance of society and government to support the sustainable management of urban goods and ecological services with the view of encouraging resilience to changing climate impacts that will support its urban security.

6.4 RECOMMENDATIONS

This section identifies through the outcomes of this study some recommendations that include institutional, scientific and policy approaches that will enhance urban environmental security for a continuously growing city such as Lagos Mega-city against the incessant negative implications of climate variability and change impacts on its residents, ecosystems, infrastructure and economy. This is in the bid to encourage the achievement of climate security in the city and with a prime goal of supporting human security and urban sustainability. Thus, the following are recommendations that are proposed in line with the study outcomes.

6.4.1 Building up of local information on climate variability and change

The study recommends proper build-up of local information on climate variability and change through relevant knowledge sharing of sustainable environmental management approaches needed for the sustainability of urban communities to the city residents and institutions by the government and other relevant bodies through appropriate media and other appropriate avenues available such as regular seminars and meetings. Information that is expected to be shared may include knowledge of changing climate and its expected mitigation, its adaptation strategies and sustainable environmental practises. Consequently, adequate sensitisation on the issues of changing climate alongside its impacts will encourage citizens of the city to support and partake in the mitigation and adaptation strategies that may be adopted for the city's environmental sustainability. Hence, sensitisation and increasing knowledge of climate will enhance the coping ability and response of the residents to issues of changing climate.

6.4.2 The need for functional weather stations for climate data

It was realised during the study that functional weather stations with up-to-date data were not readily available. Functional weather stations need to be built in different parts of the city by the government where necessary climatic information can be measured, stored, and publicly accessed. This is basically because high-quality climatic information is important in guiding policy-makers

and stakeholders in the assessment of risks and impacts associated with climate variability and change. This will further enable the delineation of useful data for scientific analysis and projections in preparation for future climate extremes. The lack of functional city weather stations with up-to-date and readily available data made vital climatic data extremely awkward to access during the study.

6.4.3 The need to maintain and improve the city's infrastructure

Critical infrastructures are essential in the protection and preservation of vulnerable communities from the negative implications of climate extreme events. Therefore, the sustainable maintenance and renovation of critical infrastructures such as the sea walls, roads, bridges and public health facilities in Lagos Mega-city by the three-tier government are vital for the Mega-city. In addition, there is a need for an integrated urban planning approach for the Mega-city. An indispensable part of the integrated urban planning approach is expected to focus on city regeneration and improvements in urban life. Additionally, the urban environmental security and climate security of the Mega-city will be improved through the provision of climate-resilient infrastructures that are essential in the mitigation of changing climate impacts. Since Lagos Mega-city is on the shorelines of both the sea and lagoons, the growing developments along shorelines should be streamlined and controlled.

6.4.4 Improvement of essential basic services provision in the city

During the survey, access to basic services was found not to be adequate in the Mega-city. This depicts vulnerability and poverty in the city. Therefore, there should be an improvement in the provision of the inadequate basic and essential services in the city such as clean water and sanitation, renewable energy facilities, power, waste management technologies, road systems, schools, health care systems, housing, recreation facilities etc. by the government and other concerned organisations to enhance human security, well-being and development. Basic services provision policy must not be discriminatory allowing for equal availability, just and access to essential services. Therefore, the delivery of basic services must not only be managed by the state

or local government alone but should include the participation of non-state actors such as NGOs, traditional leaders and community leaders for its transparency and effectiveness that will give every city dweller the right to the city.

6.4.5 Enactment of workable sustainable environmental policy

Research and documentation of issues concerning climate variability and change in the city must be supported and sustained by the state through a workable environmental policy. It's abnormal for a continuously growing mega-city such as Lagos not to have an environmental policy statement at present. This is against the progress of its urban environmental security. Hence, the city and its state government need to be identified with their 'own' environmental policy statement that will embrace their local environmental issues including the mega-city changing climate concerns, and its mitigation, and adaptation procedures. This is because a sustainable environmental policy is indispensable for the continuously growing Mega-city in this changing climate era. This policy thrust must encompass a sustainable urban environmental security strategy that will encourage climate security in the Mega-city. The policy must rest on good and effective urban governance which is essential for the city's sustainability. The policy thrust must be driven by the three-tier governments (local governments, the state government and the federal government). The policy is expected to prioritise the local content that will be essential for the sustainable management of Lagos Mega-city urban environmental security. Hence, the urban governance approach enshrined in the policy should be an all-inclusive stakeholder participation process that will foster governmental, non-governmental, inter-communities and the people. This will engender a workable and enduring system. Additionally, the policy thrust is expected to embrace the implementation of ecosystem-based preparedness to adapt, mitigate and ameliorate the impacts of climate variability and change. This includes the adoption of the emerging concept of nature-based solutions. This is an environmental management and planning tool that will make the residents and stakeholders focus on urban ecosystem restoration, preservation and sustainability. This is because, the restoration, preservation and sustainability of the urban ecosystems are indispensable in promoting livelihood opportunities for urban residents and engenders positive

impacts on the city's socio-economy. The policy must intertwine the private industries and estates in the city's sustainability, innovation and adaptation plans.

6.4.6 Initiation of sustainable urban agricultural programmes in the city

The study revealed that there has been rapid disappearance of land or its non-availability for farming activities because of the growing built environment and city dwellers' preference to use their land for other purposes. This may have negative implications for urban food security. Therefore, the study recommends that sustainable urban agricultural approaches necessary for a continuously growing city need to be encouraged by the government to sustain its urban food security. Urban agriculture has the advantage of increasing the sustainability of the supply of food and reducing carbon footprint because of its proximity to the immediate urban communities. An example is initiating community gardening to be undertaken in the remaining and available community and government lands. Community gardening is a functioning part of the nature-based solution concept being advocated as part of the environmental policy mentioned previously. This will enhance food security, promote human livelihood and increase biodiversity as well as support environmental sustainability. Also, residential gardening and innovative agricultural processes such as rooftop farming that have worked in some other cities in the world need to be embraced in the city. This is also indispensable because of the city's limited land availability for agricultural activities. Also, the city stakeholders should encourage and embrace aquaculture or aquafarming to preserve and increase the cultivation of aquatic livestock which include fishes, prawns, shrimps etc. This is on the premise (from the study) of the declining and depleting aquatic livestock. Aquaculture will enhance food security, improve the livelihoods of the residents and preserve aquatic species for the future. In addition, sustainable agricultural practices will increase employment opportunities that are veritable in improving human security and livelihoods, increasing societal coping capacity against climate variability and change impacts and vulnerability.

6.4.7 Need to focus on sustainable use of natural resources

The study identified that there was minimum use and dependence of the city dwellers on valuable natural resources. However, the city has an abundance of natural resources that could be utilised, conserved and managed sustainably for the benefit and preservation of the ecosystems and people. This includes its valuable ocean, lagoon, freshwater, etc. Hence, there is a need for the development of a sustainable plan or mechanisms that will encourage the sustainable use of the Mega-city's natural resources by the government and all stakeholders (including communities, NGOs and private enterprises). This will enhance peoples' livelihoods and environmental security. Also, it will encourage some of its residents to depend on sustainable natural capital that will invariably improve their livelihoods and increase their financial base. Therefore, policy and action plans for the sustainable use of the city's natural resources must be integrated alongside city developmental plans with consideration of the impending changing climate and prioritising conservation and preservation of the ecosystems.

6.4.8 Renewable energy sources

It was revealed in the study that the use of renewable energy sources such as solar energy, tidal energy and wind energy are virtually non-existent in the Mega-city. These sources of energy are readily available and in abundance in the Mega-city. Nearly all the Mega-city household's electrical energy sources during the study were connected to the country's electricity national grid which runs basically on hydropower whose functionality is dependent on climate variability. However, the use of renewable energy sources such as solar energy, tidal energy and wind energy are practically cleaner and sustainable processes that are indispensable in encouraging climate security apart from its support for the city's socio-economic goods that will create jobs for urban dwellers and generate lesser greenhouse gas emissions. Paraffin was acknowledged to be used by the majority of the households in the study area to power cooking. This in addition to other uses and burning of fossil fuels that were engaged in industrial activities and the city's vehicles (cars and commercial buses). This source of energy (fossil fuels) has been acknowledged universally to contribute immensely to increasing global greenhouse gas emissions that encourage changing climate. Therefore, city dwellers will need to be enlightened about the sustainability, availability,

advantages, cleaner nature, and ease of use of solar, tidal and wind energy to reduce their total dependence on the national grid, improving energy efficiency and climate security. This must be prioritised in the city's sustainability agenda. Therefore, increasing the use of renewable sources of energy in Lagos Mega-city activities will support the reduction of its carbon footprint and, therefore, enhancing its climate friendliness.

6.4.9 Improving sanitation facilities

The need to improve the sanitation facilities in the Mega-city cannot be overemphasised. This is essential for the sustainability of urban public health, socio-economy and total well-being. Evidence from the study reveals challenges in the city water security which include its domestic use and proneness to water insecurity mostly through excessive flooding in the rainy seasons. Therefore, the city government (local and state) should be committed to sustainable potable water delivery to every part of the Mega-city which is a bedrock for the provision of adequate sanitation. This should be utmost in the urban sustainability agenda of the city through the increase in the building of sustainable urban water and sanitation infrastructure that must be managed by experienced water and sanitation professionals to lessen societal disease burden. The management of the sanitation infrastructure and facilities should be open and all-encompassing with the inclusion of non-state actors (including the NGOs), representatives of the city's industrial communities and community leaders for its sustainability and effectiveness. Public-private partnership approaches may be utilised for the management of the city's sanitation facilities and infrastructure for its workability and sustainability. Also, sustainable urban planning and housing policy that would encourage the provision of essential household sanitation facilities in every home needs to be formulated, implemented and enforced in the city.

6.4.10 Recommendations for further studies

Urban environmental security is a growing developmental concept that focuses on the sustainability of the city's environmental integrity through the utilisation of diverse multidisciplinary approaches in its analyses of issues affecting urban environmental sustainability including climate variability and change. Its analysis encourages the generation of

multidisciplinary data that inspires policy analysis and formulation. Its analysis and further research are continually needed in cities in this changing climate and variability era to generate environmental and socio-economic data that are indispensable for urban planning.

Further research is essential on the relationship between biodiversity and urban environmental security in the city, especially as this study emphasised a growing depletion of biodiversity in the city with negative implications on human, livelihood and environmental security. Other research essential to be further studied alongside urban environmental security in the Mega-city is its relationship to the city's valuable natural resources. This study showed that the natural resources were minimally utilised by the residents. In addition, the survey identified the need for future studies on climate variability and change, climate security and urban environmental security in Lagos Mega-city to examine specifically the gender differences and dynamics of the city. This is based on the statistical distribution of respondents from this study (not predetermined) showing male to female ratio of 3:1. This has been found as a trend in other previous studies in the city (Lagos State, 2016; Adelekan & Asiyebi, 2016; Onwuemele, 2018; Adeniran et al. 2020). The gender differences and dynamics of the city are essential because literature depicts women and children to be more vulnerable to changing climate and climate variation.

6.5 CONCLUSION

The study evaluated the implications of climate variability and change on urban environmental security, focusing on Lagos Mega-city as a case study. Key findings include general awareness of climate issues among the respondents, but partial and limited understanding of the main contributions of socio-economic factors to climate change. Increasing intensity of temperature, rainfall, and lengthier rainy seasons were also noted, together with urban heat island effects. Climate variability was evident that affects rainfall patterns, which result particularly in increased and more severe flooding and coastal erosion. Depleting aquatic biodiversity, associated with habitat destruction and high levels of pollution, was a significant concern. Climate variability and change impacts were found to worsen socio-economic vulnerabilities, resulting in higher levels of unemployment and poverty. Adaptation strategies included livelihood diversification and increased dependence on natural resources. Lack of knowledge and institutional challenges,

however, limited adaptive capacity. Policy recommendations for enabling and improving urban environmental security and sustainability were underscored.

The concept of urban environmental security has been designed by academia and policy-makers as a paradigm engaged for the sustenance of the city's human security, institutions, environmental integrity, and sustainability. Consequently, the urban environmental security of the continuously growing cities in developing economy countries could only be retained when its resources are managed sustainably. This makes the concept of urban environmental security indispensable for the urban environments and cities in this growing changing climate era. There has been growing awareness of issues of changing climate in most developing economy countries cities like Lagos Mega-city. However, the study shows that the majority of the residents still lack the understanding and knowledge of the extent and degree of contributions of the socio-community features such as air pollution, land pollution, water pollution, burning of fossil fuels and ozone depletion to climate variability are change. The knowledge and understanding of the contributions of the parameters that instigate changing climate are essential in the promotion of sustainable climate actions that will encourage the support of sustainable climate policy by residents and stakeholders. This will invariably boost the process of achieving urban climate security.

It was also realised during the survey that critical climate data are still not readily available due to instrumental malfunctioning and unnecessary bureaucratic challenges. Yet, this study contributes by addressing some parts of the available knowledge gaps in Lagos Mega-city on the implications of climate variability and change on its urban environmental security through the assessment of the perceptions of the residents and stakeholders.

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APPENDICES

APPENDIX 1: ETHICS LETTER OF APPROVAL



28 November 2019

Mr Oluwole Olusegun Akiyode (219076946)
School of Agricultural, Earth & Environmental Sciences
Westville Campus

Dear Mr Akiyode,

Protocol reference number: HSSREC/00000502/2019

Project title: Implications of Climate Variability and Change on Urban Environmental Security: A Case Study of Lagos Mega-city, Nigeria

Full Approval – Expedited Application

This letter serves to notify you that your application received on 17 September 2019 in connection with the above, was reviewed by the Humanities and Social Sciences Research Ethics Committee (HSSREC) and the protocol has been granted **FULL APPROVAL**.

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment/modification prior to its implementation. In case you have further queries, please quote the above reference number. PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

This approval is valid for one year from 28 November 2019.

To ensure uninterrupted approval of this study beyond the approval expiry date, a progress report must be submitted to the Research Office on the appropriate form 2 - 3 months before the expiry date. A close-out report to be submitted when study is finished.

Yours sincerely,


Dr Shamila Naidoo (Acting Chair)

/ms

Humanities & Social Sciences Research Ethics Committee
Dr Rosemary Sibanda (Chair)
UKZN Research Ethics Office Westville Campus, Govan Mbeki Building
Postal Address: Private Bag X54001, Durban 4000
Website: <http://research.ukzn.ac.za/Research-Ethics/>

Founding Campuses:  Edgewood  Howard College  Medical School  Pietermaritzburg  Westville

INSPIRING GREATNESS

APPENDIX 2: HOUSEHOLD QUESTIONNAIRE

I am Oluwole Akiyode, a PhD student in the School of Agricultural, Earth, and Environmental Sciences at the University of KwaZulu-Natal, Durban, South Africa. I am undertaking a survey to assess the implications of Climate Variability and Change on Urban Environmental Security in Lagos Mega-city, Nigeria. Thereby, this questionnaire is designed for the purpose of the assessment. The information will only be used for research purposes and shall be CONFIDENTIAL. Also, your ANONYMITY will also be ensured. Your participation in this survey is voluntary and you have the right to choose NOT to participate at any given point. Grateful for your kind response, cooperation, and assistance.

Date	
Questionnaire No	
Local Government Area	
Name of Community	

RESPONDENT PROFILE

1. Gender

Male	Female
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2. Age in years.....

18-20	21-30	31-40	41-50	51-60	> 60 (specify)
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3. Marital Status

Married	Single	Divorced	Widowed	Other (specify)
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4. Highest level of formal education completed

No formal education	Partial primary	Primary completed	Partial secondary	Secondary completed	Certificate/Diploma	Undergraduate degree
Postgraduate degree	Adult Based Education (ABED)	Other (specify)				

5. Your spoken home language

English	Yoruba	Ibo	Hausa	Other (specify)
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6. Are you the household head?

Yes	No
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7. What do you do for a living (occupation)?

Formal employment in government sector	Sale of agricultural produce	Unemployed	Fishing	Pension
Formal employment in private sector	Trading/ business	Remittances	Other (specify)	

8. How much do you earn from your work engagement in monetary terms per month?

Amount in US Dollars					
Nil	<25	26-50	51-100	100-150	>150 (specify)

HOUSEHOLD PROFILE

1. What is the current household size?

No. of males		No. of females		Total	
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**2. What are the sources of income/ livelihoods that the household have access to?
(Multiple responses permitted)**

Formal employment in government sector	Sale of agricultural produce	Unemployed	Fishing	Pension	Social grants
Formal employment in private sector	Trading/ business	Remittances	Other (specify)		

3. What is the total income the household received per month from all sources?

Amount in US Dollars					
Nil	<50	51-100	101-150	151-200	>200 (specify)

4. How many years have you and your family been residing in this location in Lagos Mega-city?

Less than a year	1-5 years	5 years and above (specify)
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5. Where did you and your family reside prior to living in this location in Lagos Mega-city?

Lived in this location/ not applicable	In another area within Lagos Mega-city	In Lagos but outside Lagos Mega-City	Outside Lagos but in Nigeria	Outside Nigeria
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6. Why did you move from your previous location, if applicable?

7. Why did you move to this location (that is, what was attractive about Lagos Mega-city), if applicable?

8. Would you move out of your present location?

Yes	No	Maybe
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a. If you would consider moving (yes or maybe), why would you move?

b. If you would not consider moving (no), why would you not move?

9. Your residence is

Your own house	Rented apartment	Other (specify)
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10. The house you reside is constructed with.....

Brick and mortar (formal structure)	Informal/ shack structure	Other (specify)
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11. Which sources of energy do your household currently use? (multiple responses permitted)

Electricity	Fuelwood	Gas	Paraffin	Candles	Wind	Solar	Other (specify)
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12. What are the main sources of water for drinking and domestic use? (multiple responses permitted)

Reticulated tap water in the home	Reticulated tap water outside home (in the yard)	Boreholes	Wells	Streams	Other (specify)
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13. What are the main sources of sanitation facilities? (multiple responses permitted)

None	Formal toilet in dwelling linked to septic tank	Formal toilet outside dwelling linked to septic tank	Pit latrines	Other (specify)
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MAIN CROPS AND LIVESTOCK

1. How do you rate the quantity of your crop harvests since the past 5 or more years in your household?)

Crop	1. Greatly Increased	2. Increased	3. Remained the same	4. Decreased	5. Greatly Decreased
No crops grown					
Cassava					
Yam					
Maize					
Beans					
Fruits (e.g. mango, orange)					
Vegetables (e.g. water leaves, spinach)					
Other (specified)					

2. How do you rate the quantity of livestock you keep for the past 5 or more years in your household?

Livestock	1. Greatly Increased	2. Increased	3. Remained the same	4. Decreased	5. Greatly Decreased
Goats					
Sheep					
Rams					
Chicken/ guinea fowls					
Pigs					
Other (specify)					

MAIN SPECIES FISHED

1. How do you rate the quantity of the ocean species you source for the past 5 or more years in your household?

Ocean species	1. Greatly Increased	2. Increased	3. Remained the same	4. Decreased	5. Greatly Decreased
Bonga-Fish					
Fish-Tilapia					
Catfish					
Crayfish					
Shrimp					
Crab					
Other (specify)					

2. The natural resources available for your livelihoods is/are?

Ocean	Animals	Materials (e.g., thatch, earth., bamboo) for construction
Lagoon	Forest/ vegetation	Minerals
Fresh water	Aquatic livestock	Other (specify)

3. Levels of use of the natural resources

Natural Resources	Used			
	Daily	Once in a Weekly	Once in a month	Once in a year
Ocean				
Lagoon				
Fresh water				
Animals				
Forest/ vegetation				
Aquatic livestock				
Materials				
Minerals				
Other (specify)				

4. The financial assets you have include:

Personal account	Personal cash	Other (specify)
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5. Contribution from government or non-governmental institutions to your household in momentary value every month

Government	Non-governmental organisation (NGO)	Other (specify)
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AWARENESS OF CLIMATE VARIABILITY AND CHANGE ISSUES

1. What do you understand by climate variability and change? (Tick all appropriate)

Do not know	
Temperature increase	
Late and erratic rains	
Frequent droughts	
Frequent natural disasters such as floods	
Change in seasons	
Low crop yields	
Death of livestock	
Other (specify)	

2. Which season have you noticed the most climate variation?

Rain/ wet season	
Dry season	

3. Please rate the extent to which you believe the following aspects contribute to climate variability and change? Use the rating scale from 1 (not important at all) to 5 (very important) or Do not Know (DK)

	1	2	3	4	5	Do not know
Air pollution						
Land pollution (waste, litter)						
Water pollution (contamination of rivers, sea)						
Land clearing/ removal of trees/ forests						
Fossil fuel use						
Genetically modified crops						
Hazardous waste (chemicals, radioactive, medical)						
Loss of wildlife (animals)						
Ozone depletion						
Use of pesticides and herbicides						
Poor farming practices						
Increase in human population						
Poverty						
Traffic congestion						
Other (specify)						

CLIMATE VARIABILITY AND CHANGE IMPACTS

PHYSICAL

1. Are you aware that the annual patterns of the following are changing?

	Do not know	Yes	NO
Rainfall			
Temperature			
Frequency of flooding			
Coastal erosion			
Urban heat island			

2. In your own personal judgment, the intensity of the changes identified in the Table above in Lagos mega-city in the recent years (0-5 years) when compared to 5 years and above are:

	Do not know/ not applicable	No change	Increasing	Decreasing
Rainfall				
Temperature				
Frequency of flooding				
Coastal erosion				
Urban heat island				

3. If Yes, in your own personal judgment for the annual rainfall season in Lagos Mega-city in the recent years (0-5 years) when compared to 5 years and above is:

Longer	Shorter	No change	Do not know
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NATURAL RESOURCES

1. How has climate variability and change impacted on the availability of natural resources in your household and the community in general? (Tick those that apply)

	Household	Community in general
Fuelwood is hard to find		
Decrease in wood for construction		
Wells are drier		
Decrease in thatching grass		
Decrease in honey		
Decrease in wild animals to hunt		
Decrease in insects for food		
Decrease in wild fruits		
Decrease in fish numbers		
Decrease in fish species		
Decrease in pastures		
Soils are infertile		
Other (specify)		

AGRICULTURAL

1. How has climate variability and change impacted on agricultural production in your household and the community in general?

	Household	Community in general
Decrease in crop yield		
Decrease in crop variety		
Decrease in livestock numbers		
Death of large livestock		
Reduction in amount of land available for crop production		
Reduction in amount of land available for grazing		
Reduced sale of agricultural produce		
Low water supply		
Other (specify)		

SOCIO-ECONOMIC STATUS

1. How has climate variability and change impacted on the socio-economic status of your household and the community in general?

	Household	Community in general
Lack of help from neighbours		
Travelling long distances to get water		
Travelling long distances to get fuelwood		
Looking for other jobs		
Spending time doing extra jobs		
More strife, petty jealousies/ conflict		
Loss of family ties due to outmigration		
Higher levels of crime		
Experiencing hunger related diseases		
Experiencing water related diseases		
Children not attending to school		
Less family gatherings as time is spent fending for food		
More social gatherings to discuss issues		
More attention by government and NGOs		
Other (specify)		

RESPONSE STRATEGIES

1. How are your household and the community in general responding to climate variability and change?

	Household	Community in general
Participating more in seasonal on farm-activities as a livelihood diversification strategy		
Participating more in off-farm activities (e.g., small businesses and trade) as a livelihood diversification strategy		
More reliance on natural resources for food		
Begging		
Less fishing		
Crop diversification		
Use of more climate resilient crops and animal varieties		
Changing cropping calendar and pattern		
Changes in fishing practices		
Investing in irrigation		
Adopting water conservation measures		
Working/ farming in cooperatives		
Working for clothes and food		
Relocating some or all household members/ outmigration		
Relying on donations or grants from NGOs		
Relying on donations or grants from the private sector		
Relying on donations or grants from the government		
Other (specify)		

2. What are the challenges faced in your household or community generally to adopt climate variability and change adaptation strategies?

	Household	Community in general
Lack of knowledge and information		
Insufficient training		
Lack of capital/ funding/ money		
Labour shortage		
Lack of institutional support		
Lack of alternative sources of energy		
Lack of markets		
Transportation challenges		
Corruption and poor governance		
Other (specify)		

3. Are there opportunities/ forums to discuss climate variability and change impacts in the community?

Yes	No	Do not know
-----	----	-------------

3.1. If yes, who organised these?

Community members/ initiatives	
Government elected officials	
NGOs	
Other (specify)	

3.2.If yes, what are the household contributions in such forums?

Do not participate	
Attending meetings	
Mobilising participants for meetings	
Sharing their concerns in these meetings	
Making decisions in these meetings	
Participating in climate variability projects	
Leadership roles	
Other (specify)	

4. What types of projects (including training in the areas indicated) have been initiated externally (by government, NGOs and/ or private sector) to assist the community to adapt/ respond to climate variability and change? Please indicate also if your house benefited from such projects.

	Initiated projects	Household benefitted
Borehole drilling		
Large livestock projects		
Small livestock projects		
Forestry (including agroforestry) projects		
Conservation farming		
Community-based natural resource management projects		
Feeding schemes		
Small business projects		
Other (specify)		

5. What should be done to assist the community to adapt to climate variability and change?

QUESTIONNAIRE (In Local Language)

IBEERE

Emi ni Oluwole Akiyode, omọ ile-iwe akeeko agba patapata ni Ile-iwe ti Ogbin, Aye ati sáyènsi ni University of KwaZulu-Natal, Durban, South Africa. Mo n  e iwadi kan lati  e ayewo awon ipa ti Iyipada Afefe ati Iyipada lori Aabo Ayika Aabo ni Ilu Eko (Lagos Mega-city), ni Nigeria. Nitorinaa, a  e aper e iwe ibeere fun idi ti isayewo naa. Alaye ti o  ee fun idi iwadi yi yoo j e asiri. P elup elu, a ko ni je ki enikenii pee yin ni e dahun ibere yi. Ilowosi r e ninu iwadi yii j e atinuwa ati pe o ni eto lati yan KO lati kopa ni aaye eyikeyi ti a fun. O  eun fun esi r e, ifowosowopo, ati iranl owo.

Deeti	
Nomba Ibeere	
Local Government Area	
Oruko Adugbo	

PROFAILI OLUFEEESI

9. Idanimo

Okurin	Obinrin
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10. Ojo ori ni odun.....

18-20	21-30	31-40	31-40	41-50	51-60	> 60 (Pato)
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11. Ipo Igbeyawo

Eni to se igbeyawo	Aladagbe	Eni to tu igbeyawo ka	Opo	Omiiran (Pato)
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12. Ipele ti o ga julọ ti eto  kọ ti a pari

Ko lo si ile-iwe	Ko pari ile-eko ibere	Pari Ile-eko ibere	Ko pari secondary	Pari Secondary	Certificate/Diploma	Undergraduate degree
Postgraduate degree	Adult Based Education (ABED)	Omiiran (Pato)				

13. Ede wo ni o nso?

English	Yoruba	Ibo	Hausa	Omiiran (Pato)
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14. Se iwo ni olori ile (idile) ?

Beeni	Beeko
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15. Ki ni ise owo re?

Ise ojobo lodo ijoba	Tita oun kan ogbin	Alainise	Ipeja	Ifehinti
Ise ojobo lodo aladani	Itaje/Isowo	Awon gbigbe	Omiron (Pato)	

16. E elo ni owo to o ma ngba fun ise owo re losu?

Iye ni US Dollars					
Nil	<25	26-50	51-100	100-150	>150 (Pato)

PROFAILI IDILE

14. Kini iwon agbo ile re lowolowo?

Nomba Okurin	Nomba Obirin	Lapapo
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15. Kini awon orisun owo ti nwa fun yin/ Awon igbesi aye wo lo to aworosi yin? (O le ko esi pupo)

Ise ojobo lodo ijoba	Tita oun kan ogbin	Alainise	Ipeja	Ifehinti	Fifuni
Ise ojobo lodo aladani	Itaje/Isowo	Awon gbigbe	Omiiran (Pato)		

16. E lo ni owo ti agbo ile re gba ni osun kan lati awon orisun ki orisun?

Iye ni US Dollars					
Nil	<50	51-100	101-150	151-200	>200 (Pato)

17. Odun meelo ni iwo at agbo ile re ti gbe ni adugbo yi nilu Eko (Lagos Mega-city)?

Ko ti pe odun kan	1-5 odun	Odun 5 ati bebe lo (Pato)
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18. Ni ibo ni engbe ki eto kowa si ibi ti ewa bayi ni ilu Eko (Lagos Mega-city)?

O ngbe ni ipo yi/ Ko sise fun	Ni ibo miran ni ilu Eko	Ni ilu Eko ni ita ilu nla Eko	Ni ita ilu Eko sugbon ni Nigeria	Ita Nigeria
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19. Ki lode ti efi ko kuro ni adugbo ti ewa tele, ti ibere yi ba kan yin?

20. Ki lode ti efi ko wa si ibi ti ewa ba yi (Ki ni o wu yin ni ilu Eko), ti ibere yi ba kan yin?

21. Se e fe ko kuro ni adupo ti ew bayi?

Beeni	Beeko	Boya
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a. Ti e ba fe kokuro (Beeni tabi Boya), Ki ni idi ti e fe fi kokuro?

b. Ti eba fe kokuro (Beeko) ki ni idi ti efe fi kokuro?

22. Ile yi

E mi ni mo ko ile	Mo ya ile igbe	Omiiran (Pato)
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23. Ki ni won fi koi le ti en gbe.....

Okuta ati sementi (Igbekele ilana)	Eyi ti kise liana	Omiiran (Pato)
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24. Kini oun elo agbara ti en lo ni ile yin ni isinyi? (Agba opoplopo idahun)

Ina eletriki	Igi idana	Afefe Epo	Epo Parafin	Abela	Iji/ Afefe	Orun	Omiiran (Pato)
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25. Ki ni orisun omi mimu ati fun ilo ile yin? (Agba opoplopo idahun)

Omi paipu ninu ile	Omi paipu ni agbala	Kanga Oyinbo	Kanga	Omi to nsan	Omiiran (Pato)
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26. Ki ni akoko ohun elo lati ti se imototo (Agba opoplopo idahun)

Ko si	Ile-igbonse deede ti a sopo mo ojo omi alaikoyokan	Ile-igbonse deede lode ibugbe ti a sopo mo ojo omi alaikoyokan	Ile igbonse oni iho	Omiiran (Pato)
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AWON IRUGBIN AKOKO ATI OHUN-OSIN

3. Bawo ni os se se osuwon idiyele ti awon irugbi re ni odun marun seyin ni idi le re?

Irugbin	1. Po si gidigidi	2. Po si	3. Bakana lo wa	4. Dinku pupo	5. Dinku
Ko si awon irugbin to dagba					
Ege					
Isu					
Agbado					
Ewa					
Eso (e.g. Mangoro, Osan)					
Efo (e.g. Tete, Owo)					
Omiiran (Pato)					

4. Bawo ni ose le se osunwon idiyele awon ohun osin re ni odun marun seyin ni idi le re?

Ohu osin	1. Po si gidigidi	2. Po si	3. Bakana lo wa	4. Dinku pupo	5. Dinku
Ewure					
Agutan					
Agbo					
Adie/ Awo					
Elede					
Omiiran (Pato)					

AKOKO EYA EJA

6. Bawo ni ose le se iwon opoiye ti okun nla ti ori ni odun marun seyin ni idile re?

Ocean species	1. Po si gidigidi	2. Po si	3. Ba kana lo wa	4. Dinku pupo	5. Dinku
Eja Agbodo					
Eja-Tilapia					
Eja Aro					
Ede					
Awon eya ede					
Akan					
Omiiran (Pato)					

7. Ohu elo adayeba ti owa fun igbesi aye re ni?

Okun	Eranko	Ohun elo (e.g. Erupe, Oparun) fun ikole
Osa	Igbo	Ohun alumoni
Omi tuntun	Osin inu omi	Omiiran (Pato)

8. Awon ipele ti lilo awon oro ayebaye

Oro Ayebaye	On lo			
	Ojoojumo	Lekan ni ose kan	Lekan ni osu kan	Lekan ni odun kan
Okun				
Osa				
Omi tuntun				
Erank				
Igbo				
Osin inu omi				
Ohun elo				
Ohun alumoni				
Omiiran (Pato)				

9. Dukia owo ti o fi kun:

Apo fifipamo ti ara eni	Owo ti ara eni	Omiiran (Pato)
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10. Ilowosi lati odo ijoba tabi ile-ise ti kii se ijoba si idile re ni iye owo ni o so su

Ijoba	Ile-ise ti kii se ijoba	Omiiran (Pato)
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IMOYE TI IYIPADA AFEFE ATI ORO AYIPADA

4. Kini o loye nipase iyipade afefe ati iyipada? (Fi ami si gbogbo eyi ti o jo mo tire)

Ko mo	
Igbona po si	
Erilu ati pipe ojo	
Ogbele lorekoores	
Iseda ajalu lorekoore bi isan omi	
Iyi akoko	
Irugbin so eso kekere	
Iku eran	
Omiiran (Pato)	

5. Akoko wo ni o tise akiyesi awon iyato oju-ojo pupo julo?

Ojo/Akoko otutu	
Akoko gbe	

6. Jowo so eye ti o gbagbo pe awon ikan wonyi afefefe ni ilowosi iyapada?Lo iwon lati 1 (Ko se Pataki rara) to 5 (Ose Pataki gidigidi) or Ko mo (DK)

	1	2	3	4	5	Ko mo
Idooti Afefe						
Ile egbin (egbin/idot.)						
Omi egbin (Ibaje odo, okun)						
Fifin ile/ gige igi/ Igbo						
Ilo epo						
Titunse atileba irugbin						
Egin ewu (kemika, ohun ipanilara, egbogi)						
Ipadanu eran inu igbo						
Iparun osonu						
Lilo awon ipakokoropaeku a ti ipakokoro ewe						
Awon ise ogbin ti ko dara						
Alekun ninu olugbe eniyan						
Osi						
Ipani ijabo						
Omiiran (Pato)						

IYATO OJU-OJO ATI AWON IPA IYIPADA

TI ARA

4. Se o mo wipe apeere ododun nyipada ni awon ohun yi?

	Ko mo	Beeni	Beeko
Ojo			
Igbona			
lorekoore bi isan omi			
Ogbara eti okun			
Igbona ti ilu nla			

5. Ni idajo ti ara re, kikankikan ti iyipada ti ori ni tabili loke yi ni ilu Eko ni akoko (0-5 odun) ti o ba fiwe tieyi to ko ja odun maru si waju:

	Ko mo/ not applicable	Ko si iyato	O nposi	O dinku
Ojo				
Igbona				
lorekoore bi isan omi				
Ogbara eti okun				
Igbona ti ilu nla				

6. To ba je beeni, ni idajo tire fun ojo ododun ni ilu Eko ni aipe odun (0-5 odun) to ba fi we odun marun si waju:

O gun	O kere	Ko si iyato	Ko mo
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OHUN ELO ADAYEBA

2. Bawo ni iyato oju-ojo at iyipada lori wiwa ti awon orisun alumoni ni ile re ati agbegbe ni apapol? (Fi ami si gbogbo eyi ti o jo mo tire)

	Idile	Agbegbe ni apapo
Igi idana soro lati ri		
Idinku igi fun ikole		
Knaga ti gber		
Idinku ni koriko gbigbe		
Idinku ni oyin		
Idinku nieranko igbe lati sode		
Idinku ni awon kokoro fun ounjẹ		
Idinku ni awon eso egan		
Idinku ni number eja		
Decrease in eya eja		
Idinku ni agbegbe		
Ile ko dara fun ohungbin		
Omiiran (Pato)		

AGBE

2. Bawo ni iyipada afe fe ati iyipada oju-ojo se lori iselopo ipese ogbin ni idile re ati agbegbe ni apapo?

	Idile	Agbegbe ni apapo
Idinku ohun ogbin		
Idinku eya ohun ogbin		
Idinku ni nomba ohun osin		
Iku awon eran-osin pupo		
Idinku ni iye ile ti o wa fun ipese irugbin		
Idinku ni iye ile ti o wa fun koriko fun eran osin		
Idinku ni titaja awon ohun ogbin		
Ipese omi kekere		
Omiiran (Pato)		

IPO ORO- AJE**2. Bawo ni iyipada afefe ati iyipada ojo se ni ipa lori aje ni idile re ati agbegbe ni apapo?**

	Idile	Agbegbe ni apapo
Aini iranlowo lati odo awon aladugbo		
Ririn irin-ajo gigun lati lo pon omi		
Ririn irin ajo gigun lati lo gba igi idana		
Nwasw miran		
Lilo akoko lati se awon ise miran		
Ija die, Jije owu, rogbodyan		
Ipadanu awon asopo ebi nitori ilokuro		
Ipele giga ti awon odaran		
Iriri awon arun ti oni ibatan		
Iriri awon arun ti ko ba omi tan		
Awon omode ko wa si ile-iwe		
Idinku apejo idile nitori wa lofun at pese fun ounje		
Iposi apejo awujo die sii lati jiroro oro		
Iposi ifeti sile ijoba ati awon ilese ti ki se ti ijoba (NGO)		
Omiiran (Pato)		

OGBON FUN ESI**6. Bawo ni idile re ati agbegbe re se dahun si lapopo se si iyipada afefe ati iyapada ojo?**

	Idile	Agbegbe ni apapo
Kikopa die si ni asiko-lori awon ise lori ile bi ilana isodipupo igbesi aye		
N kopa die sii ninu awon ise agbe (fun apeere awon isowo kekere ati isowo) bi ilana idawole igbesi aye		
Gbe igbekele die lori awon orisun alumoni fun ounje		
Ma bebe		
Ipeja kekere		
Gbin irugbin ti oyato sira won		
Lilo die sii awon irugbin to le farada iyipada afefe ati awon eranko		
Iyipada kalenda ati bi ati gbin ohun ogbin		
Iyipada bi ase npeja		
Idokowo ona ati gbe omi si oko		
Gba si awon ona itoju omi		
Shise ise ogbin ni awon ifesowopo		
Shise fun awon aso ati ounje		
Lati je ki ara ile or gbobgo ile ko logbe ibomiranIle		
Duro lori awon ifunni lati odo awon NGO		
Duro lori awon awon ifunni lati owo aladani		
Duro lori awon awon ifunni lati odo ijoba		
Omiiran (Pato)		

7. Kini awon italaya ti o dojuko ninu ile re tabi agbegbe re ni lati gba ogbon ati iye lati fradaiyipada afele ati iyipada ojo?

	Idile	Agbegbe ni apopo
Idanileko ti kope		
Aini oye ati alaye		
Aini owo		
Aini atileyin awon eleto		
Aini awon orisun omiiran fun agbara		
Aini awon oja		
Awon italaya oko		
Iwa ibaje ati buburu ijoba		
Omiiran (Pato)		

3. Nje awon aye apejo wa lati jiroro lori iyipada afele ati awon ipa iyipada ojo ninu agbegbe re?

Beeni	Beeko	Ko mo
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3.1 Ti o ba je beeni, ta ni o seto re?

Awon omo agbegbe	
Osise ijoba	
NGOs	
Omiiran (Pato)	

3.2 Ti o ba je beeni, kini awon ara idile re fun awon apejo na?

Mi o kopa	
Anwa si awon ipade	
Anpe awon olukopa fun awon ipade	
Pinpin awon ifiyesi won ninu awon ipade wonyi	
Shise awon ipinnu ni awon ipade wonyi	
Kopa ninu awon ise iyipada oju-ojo	
Awon ipa olori	
Omiiran (Pato)	

4. Awon oriṣi iru awon iṣe (peḷu ikeko ni awon agbegbe ti a fi han) ni won ti bere (lati odo ijoba, NGO ati / tabi aladani) lati se iranlowo fun agbegbe lati dahun si iyipada afele ati iyipada ojo? Jowo toka si ti ile re ba wa lara awon iru awon iṣe be

	Ipilẹse ise	Idile to sefani
Kanga gbigbe		
Awon iṣe agbe eran nla		
Awon iṣe-osin kekere		
Itoju igbonla (peḷu sin eran osin ni igbo nla)		
itoju ise Ogbin		
Awon iṣe akanse orisun iseda aye ti orisun agbegbe		
Awon igberoja kikoj		
Awon iṣe isowo kekere		
Omiran (Pato)		

5. Kini oye ki as lati se iranlowo fun agbegbe lati feramo si iyato afele ati iyipada ojo?

APPENDIX 3: KEY INFORMANTS INTERVIEW GUIDE

1. What is the name of your organisation?
2. How many years have you been working and residing in Lagos mega-city?
3. Are you aware that there is climate variability and change?
4. Are you of the opinion that climate variability and change has impacts on Lagos mega-city?
5. How does your department perceive climate variability and change impacts in the city?
6. Kindly mention the impacts of climate variability and change on the city of Lagos
7. Are you aware of any kind of coping abilities/ adaptation procedures that is engaged by the residents against the impacts of climate variability and change in Lagos mega-city?
8. Kindly, mention the coping abilities/adaptation procedures that you know that are being engaged.
9. How is your department encouraging coping or adaptations to impacts of climate variability and change impacts in Lagos mega-city?
10. Are there training initiatives in relation to climate variability and change adaptation, and if so, what are these?
11. What are the contributions of your department in enhancing the coping abilities of Lagos residents to impacts of climate variability and change?
12. Does the government have policy statements on climate variability and change?
13. What are the policies that are guiding adaptation and mitigation of climate variability and change?
14. Is there a structure that encourages adaptation to climate variability and change in this city?
15. What is the policy thrust engaged by your department or the government in encouraging coping abilities of the Lagos mega-city residents to impacts of climate variability and change?

APPENDIX 4: FOCUS GROUP DISCUSSIONS QUESTIONS ON LEADERS OF THE COMMUNITIES AND FISHMONGERS

1. What do you understand by climate variability and change?
2. Are you of the opinion that the climate variability and change has impacts on Lagos mega-city?
3. Kindly mention the impacts of climate variability and change on the city of Lagos that you are aware of?
4. What are the effects of climate variability and change on aquatic livestock in your communities when you compare recent years (0-5 years) to 5 years and above?
5. How do the impacts of climate variability and change affect the livelihoods of the residents of your community?
6. Are you aware of any kind of coping abilities/ adaptation procedures that is engaged by the residents against the impacts of climate variability and change in Lagos mega-city?
7. Are you aware of any kind of policy thrust on the part of the government or your community that is set to encourage residents' coping abilities to the impact of climate variability and change?
8. Are you aware of any mitigation approaches engaged by your community or the government against the impacts of climate variability and change in your community?

Yoruba Language

Awon ibeere ti Focus Group Discussions lori awon olori ti awon tin gbe ni agbegbe awon Eleja

1. Kini o mo nipa iyipada afefe ati iyipada ojo?
2. Nje o ro pe iyipada afefe ati iyipada ojo ni ipa lori ilu mega ilu Eko?
3. Fi inu didn daruko awon ipa ti iyipada afefe ati iyipada ojo ni ilu Eko ti o mo?
4. Kini awon ipa ti iyato oju-ojo ati asewori aquatic ni agbegbe re nigbati o ba se afiwe awon odun aipe (odun 0-5) si odun marun 5 ati loke?
5. Bawo ni awon ipa ti iyipada afefe ati iyipada ojo lori igbesi aye awon olugbe ti agbegbe re?
6. Se o mo iru eyikeyi awon ipa ipa fara ti awon olugbe ngbe nipase awon ipa ti iyato iyipada afefe ati iyipada ojo ni ilu mega-ilu Eko?
7. Nje o se akiyesi iru eto imulo eyikeyi ni apakan ti ijoba tabi agbegbe re ti seto lati se iwuri fun ipa awon olugbe lori iyipada afefe ati iyipada ojo?
8. Se o mo nipa eyikeyi awon ona isunmo ti agbegbe re tabi ijoba n se lodi si awon ipa ti iyipada afefe ati iyipada ojo ni agbegbe re?