EVALUATION OF CLIMATE AND ENVIRONMENT-INDUCED MIGRATION IN NIGERIA

BY

AWEDA, Emmanuel Damilola

PhD/SPS/FT/2021/13011

WEST AFRICAN SCIENCE SERVICE CENTRE ON CLIMATE CHANGE AND ADAPTED LAND USE, CLIMATE CHANGE AND HUMAN HABITAT (WASCAL CC&HH)

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGERIA

MARCH, 2025

EVALUATION OF CLIMATE AND ENVIRONMENT-INDUCED MIGRATION IN NIGERIA

BY

AWEDA, Emmanuel Damilola

PhD/SPS/FT/2021/13011

THESIS SUBMITTED TO THE POSTGRADUATE SCHOOL, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGERIA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF DEGREE OF DOCTOR OF PHILOSOPHY (PhD) IN CLIMATE CHANGE AND HUMAN HABITAT

MARCH, 2025

DECLARATION

I hereby declare that this thesis titled: **“Evaluation of Climate and Environment-Induced Migration in Nigeria”** is a collection of my original research work and has not been presented for any other qualification anywhere. Information from other sources (published or unpublished) has been duly acknowledged.

AWEDA, Emmanuel Damilola ……..…………..………..…

PhD/SPS/FT/2021/13011 Signature/Date

Federal University of Technology

Minna, Nigeria

CERTIFICATION

The thesis, titled: **"Evaluation of Climate and Environment-Induced Migration in Nigeria"** by: AWEDA, Emmanuel Damilola (PhD/SPS/FT/2021/13011) meets the regulations governing the award of the degree of PhD of the Federal University of Technology, Minna and it is approved for its contribution to scientific knowledge and literary presentation.

Prof. A. A. Okhimamhe	………………………...
Major Supervisor	Signature & Date
Prof. C. Conrad	………………………...
Co-Supervisor	Signature & Date
Prof. A.A. Okhimamhe	………………………...
Director of WASCAL, DRP-CC&HH	Signature & Date
Prof. A.N. Saidu	………………………...
Dean of Postgraduate School	Signature & Date

DEDICATION

To the King eternal, immortal, invisible, the only wise God, be honour, glory and dedication of this research work forever and ever. Amen.

ACKNOWLEDGEMENTS

My sincere appreciation goes to the management and staff of the West African Science Service Centre on Climate Change and Adapted Land Use (WASCAL), Rural-urban and cross-border MIGRAtion in West-Africa - an integrated assessment framework of drivers, processes and sustainable REsponses (MIGRAWARE), and the German Federal Ministry of Education and Research (BMBF) for providing the support to embark on this programme.

My profound and sincere gratitude goes to my supervisors, Prof. Appollonia Okhimamhe and Prof. Dr. Christopher Conrad whose invaluable advice, timely guidance, courteous comments, supportive interest and relentless efforts have propelled this project to its successful completion. Special appreciation goes to the amazing staff of the Doctorate Research Programme. Climate Change and Human Habitat of WASCAL, Federal University of Technology, Minna: Prof. Appollonia Aimiosino Okhimamhe, Dr Emmanuel Umaru, Dr (Mrs) Mary Odekunle, Dr (Mrs) Julie Elche, and Dr Isaiah Sule. I also appreciate the special support I enjoyed from Mrs Lucy Peters, Engr. Ralph Agboola, Mr. Abdulrahman Yahaya and Miss Sidikat Aliyu.

I especially appreciate the members of staff and research group of the Department of Geoecology, Institute for Geosciences and Geography, Department of Geoecology, Martin Luther University Halle-Wittenberg, Halle, Germany, for their encouragement and support during my scientific visit to their institution.

I am deeply grateful to the Nigerian Meteorological Agency, Scripture Union (Nigeria), Ikorodu Zone, The Redeemed Christian Church of God (Abeokuta), House on the Rock (Minna) and Resurrection Power Ministry International (Halle-Saale, Germany). My heartfelt gratitude goes to Prof. P.A.O. Odjugo, Prof. O. J. Olaoye, Dr. Sunday Okeleye, Miss Alina Schurmann and Mr. Augustine Eke for their care throughout this study. I appreciate the great support I enjoyed from my great colleagues: Rotimi Obateru, Deborah Ishaku, Olivier Ahouandjinou-Enagnon, Aliou Gadiaga, Mariama Cisse, Dicko Kagou, Kadiza Seydou, Youssoufa Doulla Nouhou, Alex Koffi, and Adjouwa Tossoukpe.

My endless gratitude to my dear wife, Mrs. Janet Aweda and my lovely children, Enoch and Elisha Aweda, for their patience and understanding during this PhD study. My appreciation goes to my ever-supporting parents, Professor and Mrs. Moses Aweda; my siblings, Esther Aweda, Daniel Aweda and Ruth Fadare; the Olaniyans, the Akinpelus, the Adeboris, the Fadares, and all my well-wishers for their spiritual and emotional support throughout my period of study.

Above all, I appreciate God, the giver of wisdom, knowledge, understanding, and good and perfect gifts for His love and care during my PhD study at the Federal University of Technology, Minna, Niger State, Nigeria.

ABSTRACT

Migration has been recognised as a coping mechanism in response to escalating climate change and environmental degradation globally, particularly in Sub-Saharan Africa, where Nigeria is located. The search for livelihood opportunities and improved living conditions, among other underlying factors, makes migration complex and multifaceted. Employing a mixed-methods approach, this study integrates remote sensing and climate data (1993 to 2022) with household surveys (n = 1080) and focus group discussions across selected hotspots in Nigeria. This study revealed a significant increase in temperature at the migration origins in Kano Municipal, Kwali; and sea level rise in coastal communities of Warri South-West and Brass ($p < 0.05$). The study provided empirical evidence of a paradox: despite the established environmental and climatic changes, there was a notable reluctance to migrate. While perceptions of migration drivers were consistent across the communities ($H = 8.108$, $p = 0.423$), socioeconomic factors, particularly the pursuit of job opportunities (35 percent) and business/trading prospects (29 percent), were identified as the major drivers of migration. Climate and environmental factors were cited by 11 percent of the migrants, with persistent drought (32 percent) and inadequate rainfall (27 percent) being the major climatic drivers. Destination communities in Fagge, Kano Municipal, Gwagwalada, and Kwali faced significant variations in challenges due to migration ($H = 41.729$, $p < 0.05$). These challenges were competition for jobs (43.7 percent), insecurity (23.2 percent), pressure on agricultural lands (11.7 percent), pressure on environmental resources (10.7 percent), land degradation (7.6 percent), and pressure on land for development (3.4 percent). Furthermore, there was a significant variation among communities regarding who should be responsible for leading interventions related to climate and environment-induced migration ($H = 37.327$, $p < 0.05$). The findings imply that while socioeconomic factors are the major drivers, environmental and climatic changes were critical in influencing migration decisions. This study thus advocates for multi-stakeholder partnerships to develop tailored strategies to address climate and environment-induced migration in Nigeria.

TABLE OF CONTENTS

Contents **Page**

LIST OF TABLES

LIST OF FIGURES

Figure **Page**

LIST OF PLATES

Plate **Page**

LIST OF APPENDICES

Appendix **Page**

GLOSSARY OF ABBREVIATIONS

ANOVA: Analysis of Variance

C3S: Copernicus Climate Change Service

CHIRPS: Climate Hazards Group InfraRed Precipitation with Station data

ECMWF: European Centre for Medium-Range Weather Forecasts

EA: Enumeration Area

ERA-5: Fifth Generation of ECMWF Reanalysis

FGD: Focus Group Discussion

GEE: Google Earth Engine

GPS: Global Positioning System

ITD: Inter-Tropical Discontinuity

IOM: International Organisation for Migration

IPCC: Intergovernmental Panel on Climate Change

KPI: Key Performance Indicators

LGA: Local Government Area

LULC: Land Use and Land Cover

MODIS: Moderate Resolution Imaging Spectroradiometer

MFCV: Mangrove Forest and Coastal Vegetation

NASA: National Aeronautics and Space Administration

NASPA: National Adaptation Strategy and Plan of Action

NCRS: National Centre for Remote Sensing

NCFRMI: National Commission for Refugees, Migrants and Internally Displaced Persons

NDBI: Normalised Difference Built-up Index

NDC: Nationally Determined Contributions

NDVI: Normalised Difference Vegetation Index

NELM: New Economics of Labour Migration

NEMA: National Emergency Management Agency

NES: Nigerian Environmental Society

NESREA: National Environmental Standards and Regulations Enforcement Agency

NGO: Non-Governmental Organisation

NIMET: Nigerian Meteorological Agency

NOA: National Orientation Agency

NOMRA: Network of Migration Research on Africa

OLI: Operational Land Imager

SDG: Sustainable Development Goal

SSEZ: Sudano-Sahelian Ecological Zone

SPEI: Standardised Precipitation Evapotranspiration Index

SPI: Standardised Precipitation Index

SSRN: Sudano-Sahelian Region of Nigeria

UNDP: United Nations Development Programme

UNEP: United Nations Environmental Programme

VCI: Vegetation Condition Index

WMO: World Meteorological Organisation

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

At the turn of the 20th century, the world began to acknowledge the existence of a changing environment and climate, which has remained a global phenomenon and source of concern to this day. This has produced adverse effects such as land degradation, food insecurity, health challenges, and extreme weather events (Wang *et al*., 2023). The significant changes in the environmental and climatic conditions have proven to be an irresistible force that has triggered human migration from one location to another as a means of adaptation (Hermans and McLeman, 2021). Therefore, it is imperative to obtain comprehensive evidence of this relationship, with a particular focus on the environmental and climate-related factors that drive migration and its resulting impacts.

With the turn of events, human migration's social and economic implications have remained a source of concern to researchers and policymakers. This is reflected in one of the 2030 Sustainable Development Goals (SDGs) targets (10.7), which is to "facilitate orderly, safe, and responsible migration and mobility of people, including through implementation of planned and well-managed migration policies." This can be related to SDG 13, which is centred on climate action, thereby making researchers sometimes describe migration as the "human face" of climate change, which can also be read as a gauge of both resilience and vulnerability (Bettini and Gioli, 2016; Wiederkehr *et al*., 2019). The movement of people due to the changing climate and environment may be non-voluntary or voluntary, temporary or permanent, and may occur at the internal or international level.

In recent times, human migration has been severely affected by the scourge of the coronavirus pandemic (SARS-CoV-2), which has resulted in the Coronavirus Disease 2019 (COVID-19) pandemic, the most significant global health calamity of the 21st century and the most significant challenge to humankind since the Second World War (Chakraborty and Maity, 2020). Lockdowns and movement restrictions were introduced as a measure to limit the spread of the pandemic. This had huge negative economic impacts, leading to increased food insecurity within and across countries, thereby influencing both internal and international migration across various locations after the easing of the restrictions and lockdowns (Shah *et al*., 2020). The changing climate and environment have generally been viewed as one of the drivers of migration due to temperature rise, changing rainfall patterns, rising sea levels, and ever-increasing extreme weather events. Therefore, migration occurs as a response and means of adaptation to these changes, making it the dependent variable. In contrast, the changing climate and environment influencing this response become the independent variable. The movement of people in response to the changing climate and environment may be forced or voluntary, temporary or permanent, and internal or international.

In light of the growing consensus among scientists from diverse fields that environmental degradation and climate change are among the most pressing global challenges, there is a growing recognition of the need to consider the study of human migration as a potential response to these challenges (Ferris, 2020). Globally, environmental and climate change impacts on migration are evident in countries like Bangladesh and low-lying Pacific Ocean Island nations. In Bangladesh, persistent flooding and rising sea levels have driven millions of people to migrate from coastal communities to urban areas, increasing the challenges in densely populated cities (Chen and Mueller, 2018). This is similar to the Pacific Islands, where whole communities are endangered by existential threats due to rising sea levels. This has forced the communities to consider relocating to other countries (Perumal, 2018). These examples show the deep effects of the changing environment on human displacement, pointing out the need for immediate adaptive responses.

Recent World Bank reports have also highlighted the huge prospect of internal migration driven by climate change in Latin America, the Middle East, North Africa and sub-Saharan Africa (Rigaud *et al*., 2018). Sahelian Africa experiences severe droughts and land degradation, forcing pastoralist communities to migrate for water and pasture. This is a similar pattern in Nigeria, especially in the north, where severe droughts, famines, and high variability in weather and climate patterns usually result in environmental degradation and migration (Odoh and Chilaka, 2012; Olagunju *et al*., 2021). The shrinking of Lake Chad, for instance, has disrupted livelihoods, forcing thousands to migrate in search of better conditions. In the past 50 years, over 75 percent of northern Nigerians have relied on subsistence agriculture. The changing climate and environment have resulted in a significant decline in crop yields and high mortality rates among animals (Ikhuoso *et al*., 2020). These situations would mean loss of livelihood, prompting the migration of households in search of greener pastures, establishing the connection between environmental degradation, socio-economic issues, and migration. The years of persistent droughts in Nigeria's savannah region have led to land degradation through severe deforestation and unsustainable agricultural practices (Azare *et al*., 2020). These have seriously affected the productivity of lands and thus prompted farmers to migrate to other more productive lands or subsistence areas, which may be international (cross-border) or internal (rural-urban or vice versa).

The largest type of migration flow in Nigeria is rural-to-urban migration, which accounted for approximately 60 percent of internal migrants in 2010. This migration is driven by the search for more favourable economic opportunities in urban areas, particularly among young people whose livelihoods have been adversely affected by the decline in agricultural productivity resulting from climate change (Halliru *et al.*, 2024). Nigeria has been projected to have the second-highest mean number of internal climate migrants in West Africa by 2050 (8.3 million) under the pessimistic scenario. Furthermore, the country is estimated to have the greatest number of coastal climate out-migrants, with an estimated one million by 2050 under the high-end distribution for the pessimistic scenario (Rigaud *et al*., 2021). This indicates a link between Nigeria's changing environment/climate and migration. Socioeconomic factors influence migration patterns, which make individuals and households more susceptible to forced migration (Castelli, 2018). The complex relationships between these factors are a major challenge, especially to address the needs of those mostly affected by these changes.

In light of the prevailing evidence concerning the impact of climate change, particularly concerning migration, this study is set up to provide a better understanding of the environment and climate-induced drivers of migration in Nigeria. By considering key environmental parameters such as vegetation, precipitation, temperature, and sea-level rise, this research project seeks to provide insights into the relationship between environmental factors and climate change and the phenomenon of migration, contributing to the ongoing discussions on migration as an adaptation strategy to the changing environment/climate in Nigeria. The contributions made by this study are in identifying these migration drivers and providing empirical information on their extent of influence, in comparison with other drivers. This will aid in informing policies and strategies to mitigate the environmental and climatic impacts on human mobility and support household and community resilience.

1.2 Statement of the Research Problem

The agricultural sector has a considerable influence on Nigeria's economy. Crop production, animal husbandry, and fishing are notable sources of livelihood for households throughout the country (Olomola and Nwafor, 2018). The country is confronted with mounting challenges, many of which are directly due to environmental degradation and climate change. Among these challenges are the rising sea levels in coastal areas, frequent flooding, drought, and desertification in the Savannah regions (Adetoro *et al*., 2022). These changes have increased the socio-economic vulnerabilities, which have led to a rise in rural-urban migration and put a strain on the destination communities, which are already struggling with inadequate infrastructure, limited housing, and high unemployment rates. Without effective intervention, the pressures on the destination communities will likely lead to increased social tensions, resource conflicts, pressure on land for development and land degradation.

Ideally, Nigeria should have a well-developed working system to mitigate the impacts of the changing climate and environmental degradation. This will enhance the resilience of vulnerable communities to environmental stressors, such as extreme temperatures, droughts, rising sea levels, and floods. Such fact-based, integrated insights are crucial for policymakers and stakeholders in addressing these migration drivers and contributing to sustainable development. This aligns with achieving SDGs 10.7 and 13's focus on orderly, safe migration and climate action (Adger *et al*., 2019; Wilkinson *et al*., 2022).

Realistically, there is an inadequate empirical understanding of specific drivers, patterns, and impacts of environment and climate-induced migration in Nigeria. Furthermore, the current policy frameworks are not informed by local data. This results in gaps between the actual environmental and climatic impacts on migration and the strategies required to manage them effectively. If these gaps in knowledge persist and no decisive action is taken, the impact of environmental degradation and a changing climate on migration may become more severe. The continuous migration may place unsustainable pressure on the destination communities, further depleting resources and undermining efforts toward sustainable development, which may fuel social unrest and instability.

While these challenges are gaining more recognition, existing general studies have presented various models and theories not tailored to Nigeria's unique socioeconomic and ecological landscape. The lack of community-specific insights may hinder policymakers' ability to develop targeted interventions, such as early warning systems and climate-resilient infrastructure. Consequently, there is an urgent need for a research study to address this gap by providing detailed, evidence-based insights into the dynamics of environment and climate-induced migration in Nigeria. This study aims to address this gap by offering empirical evidence and tailored policy recommendations, thereby contributing to academic understanding and practical solutions for managing environmental and climate-induced migration in the region.

1.3 Research Questions

To bridge these gaps, this study aims to contribute answers to these research questions:

i. What are the trends of ecological health and climate indicators at the migration origins in Nigeria?

ii. What are the sociodemographic characteristics of the household heads at the origin and destination hotspots of Nigeria?

iii. What are the migration patterns at Nigeria's origin and destination hotspots?

iv. To what extent do the socioeconomic, climatic and environmental drivers influence migration within Nigeria?

v. How does migration impact the destination communities in Nigeria?

1.4 Aim and Objectives

This study aims to examine the influence of climatic and environmental factors on migration and the consequences on destination communities in Nigeria.

The specific objectives of this study are to:

i. Identify and analyse the trends of ecological health and climate indicators at the migration origins in Nigeria
ii. Assess the sociodemographic characteristics of the household heads at the origin and destination hotspots of Nigeria
iii. Identify the migration patterns at the origin and destination hotspots of Nigeria
iv. Assess the socioeconomic, climatic and environmental drivers of migration in Nigeria
v. Evaluate the impacts of migration on destination communities in Nigeria

1.5 Justification for the Research

The following are the justifications for this research study**:**

(a) Policy Improvement: Nigeria is one of the countries where vulnerable people are disproportionately affected by the changing climate and environmental degradation. Given that several environmental stressors continue to influence households to migrate, it becomes imperative that policymakers understand and address these migrations' intricate patterns. Currently, the existing policies do not include sufficient details that can be used to identify and address specific community problems when it comes to mitigating climate and environmental impacts. In developing adaptation strategies for different regions and communities, considering each location's unique environmental challenges and socioeconomic factors is essential. The findings from this study will be useful to the Federal Ministry of Environment of Nigeria, in conjunction with related government departments, by assisting them in the top design of strategic response frameworks against climate impacts and environmental degradation throughout the country. This will help mitigate climate- and environment-induced human migration through adequate policy development and implementation.

While environment and climate-related policies in Nigeria focus on mitigation and adaptation, migration is often overlooked as a critical component. The results from this study will help integrate migration management strategies into national climate action plans and frameworks. This integration will ensure that migration is perceived as an adaptive strategy and a consequence of environmental change.

(b) Performance Improvement: This study is crucial in understanding the underlying causes and patterns of migration and improving the performance of various stakeholders (such as government agencies, community leaders, political leaders, religious leaders and non-governmental organisations) involved in managing the environment and climate-induced migration. This supports more timely and informed decision-making processes, leading to improved interventions and more effective use of resources. While aiding collaborative efforts among agencies dedicated to migration issues, such as the International Organisation for Migration (IOM), the National Commission for Refugees, Migrants and Internally Displaced Persons (NCFRMI), The Federal Ministry of Environment, Network of Migration Research on Africa (NOMRA), the United Nations Development Programme (UNDP), and United Nations Environmental Programme (UNEP), this study demonstrates the necessity for community participation in migration studies and contributes towards implementing more pertinent and enduring interventions, as local knowledge and priorities are integrated into planning processes.

(c) Body of knowledge: It is important to understand how the degrading environment and changing climate influence human migration from an academic, policy, and practical perspective. The traditional push-pull migration model often emphasises economic and social factors, focusing less on environmental influences. However, this study allows for an improved understanding of migration dynamics by expounding on how environmental changes, such as temperature rise, precipitation changes, droughts, floods, and sea level rise, serve as catalysts for migration. In addition to highlighting the opportunities and challenges facing communities that welcome migrants, this study provides implications for Nigeria on environment and climate-induced migration.

(d) Further Research: Short-term and long-term environmental changes influence the dynamic migration process. Due to the intricate and dynamic nature of the topic, this study provides a foundation for future research, particularly by involving local communities.

1.6 Description of Study Area

1.6.1 Geographical location and map of study

Nigeria, a West African country, lies between the latitudes 4°– 14° north of the Equator and the longitudes 3°–14° east of the Greenwich Meridian (Figure 1.1). Nigeria shares borders with the Niger Republic to its north, the Gulf of Guinea to its south, Cameroon and Chad to its east, and Benin Republic to its west. Nigeria, the most populous country in Africa, has a total land area of approximately 923,769 km^2, encompassing a vast array of vegetation across its diverse climatic zones (Igbawua *et al*., 2022).

The study focused on selected locations across the nation's Mangrove Forest and Coastal Vegetation, Guinea Savanna, and Sudano-Sahelian Savanna regions, as shown in Figures 1.1 and 1.2. These hotspots were selected based on the "intersection" of geopolitical and ecological zones, as illustrated in Table 1.1.

Table 1.1: Description of the Study Locations

Agroecological Zone	State	LGA	Community	Location
Mangrove Forest	Delta	Warri South West	Ugborodo	5.60ºN, 5.18ºE
and Coastal			Ogidigben	5.56ºN, 5.18ºE
Vegetation	Bayelsa	Brass	Twon	4.31ºN, 6.24ºE
			Odioma	4.33ºN, 6.43ºE
Guinea Savanna	Abuja	Gwagwalada	Zuba	9.09ºN, 7.22ºE
			Tungamaje	9.06ºN, 7.21ºE
		Kwali	Central	8.82ºN, 7.04ºE
			Wako	8.60ºN, 6.91ºE
Sudan-Sahel	Kano	Kano Municipal	Zango	12.00ºN, 8.53ºE
Savanna			Tundun Nufawa	11.99ºN, 8.51ºE
		Fagge	Sabon Gari East	12.05ºN, 8.54ºE
			Sabon Gari West	12.02ºN, 8.53ºE

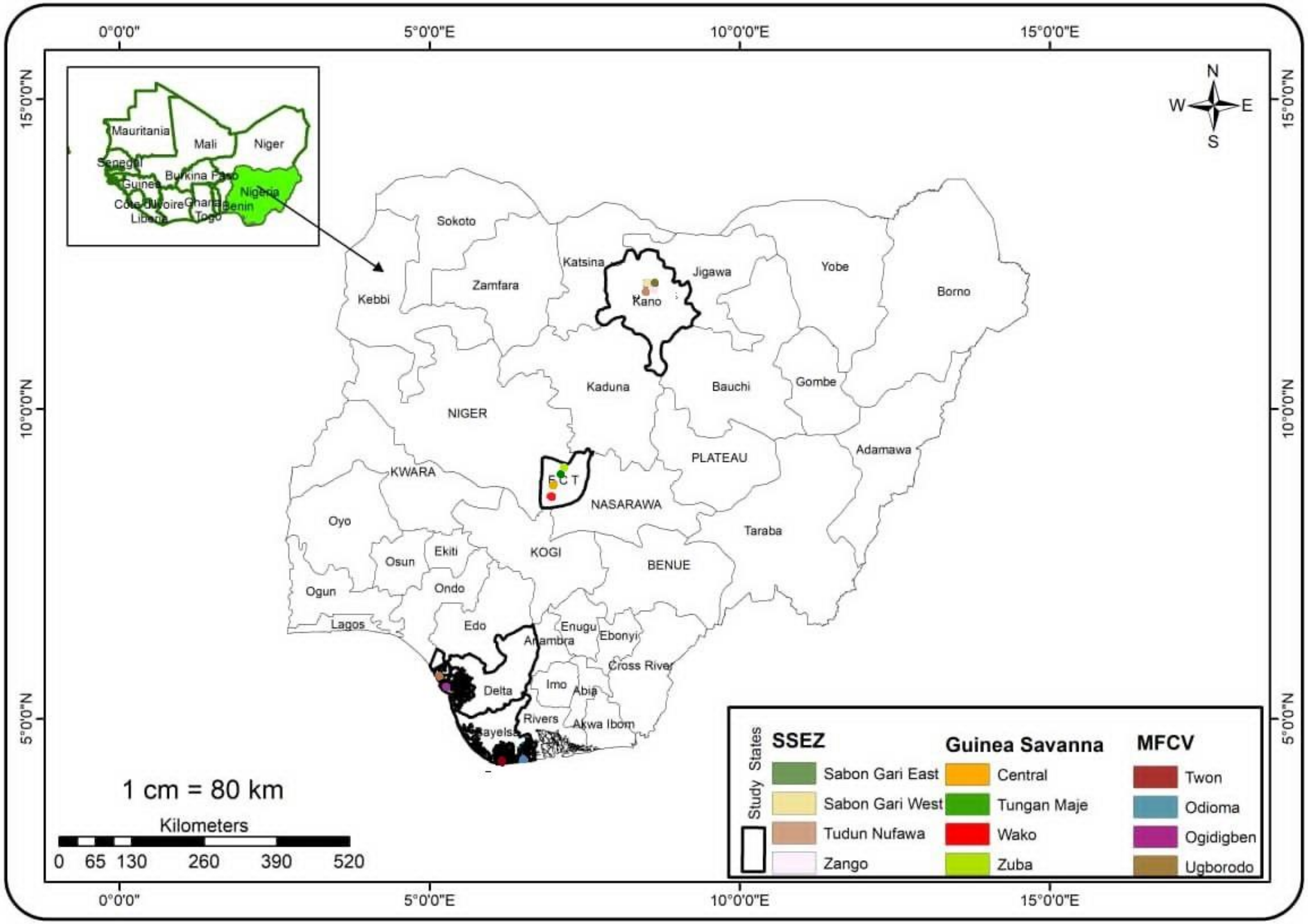


Figure 1.1: Locations of the Study Communities

Nigeria's Mangrove Forest and Coastal Vegetation (MFCV) is located between 4ºN – 6ºN and is the largest in Africa, ranking among the largest in the world. It is among the most ecologically significant and biodiverse ecosystems in the country, playing a critical role in environmental sustainability, climate regulation, and local livelihoods. These ecosystems are primarily concentrated in the Niger Delta region, which hosts one of the largest mangrove forests in Africa and the third largest in the world, covering approximately 10,000 square kilometers (Zabbey *et al*., 2019). The Guinea Savanna region is situated at 8ºN and 11ºN and is located in the middle of Nigeria, and is the most extensive ecological zone (Adenle *et al*., 2020) and it is sandwiched. The Sudano-Sahelian Ecological Zone (SSEZ) is situated in northern Nigeria between latitudes 11°N and 14°N, extending from the Sokoto plains through the northern portion of the high plains of Hausa land. Figure 1.2 shows the country's ecological zones.

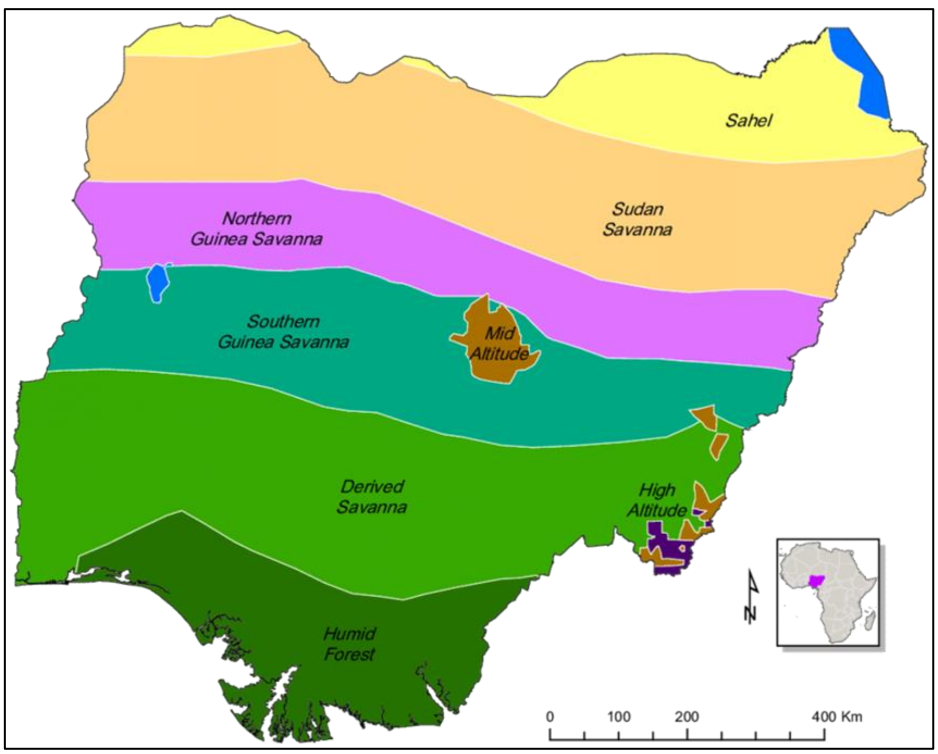


Figure 1.2: Map of Nigeria Showing the Ecological Zones (Dawi *et al*., 2017)

1.6.2 Climate

Nigeria’s climate is typically tropical and humid, influenced by the fluctuations of the dry tropical north-easterly winds in dry seasons, and the moist tropical maritime airmass (south-westerly wind) in wet seasons (Ajao *et al*., 2020). The intertropical discontinuity (ITD) separates the two air masses, with an annual north-south oscillation pattern, thereby influencing precipitation and convective activities. Nigeria's climate is increasingly influenced by climate change, manifesting in more erratic rainfall patterns, prolonged droughts, rising temperatures, and more frequent extreme weather events such as floods. These changes have profound implications for agriculture, water resources, and human settlements.

The southernmost position of the ITD (approximately 5°N) is attained in January, while the northernmost position (approximately 22°N) is reached in August (Odekunle *et al*., 2024). The hottest parts of the country include the extreme northwest and northeastern fringes, while the highlands experienced lower temperatures (Figure 1.3). The precipitation level declines from the MFCV region of Nigeria, with a near-year-round level of approximately 3,500 to 4,000 mm in the northern region and across the agroecological zones, and a markedly lower level of about 500 mm in the SSEZ, particularly in the extreme northeastern area (Shiru *et al*., 2020) (Figure 1.3).

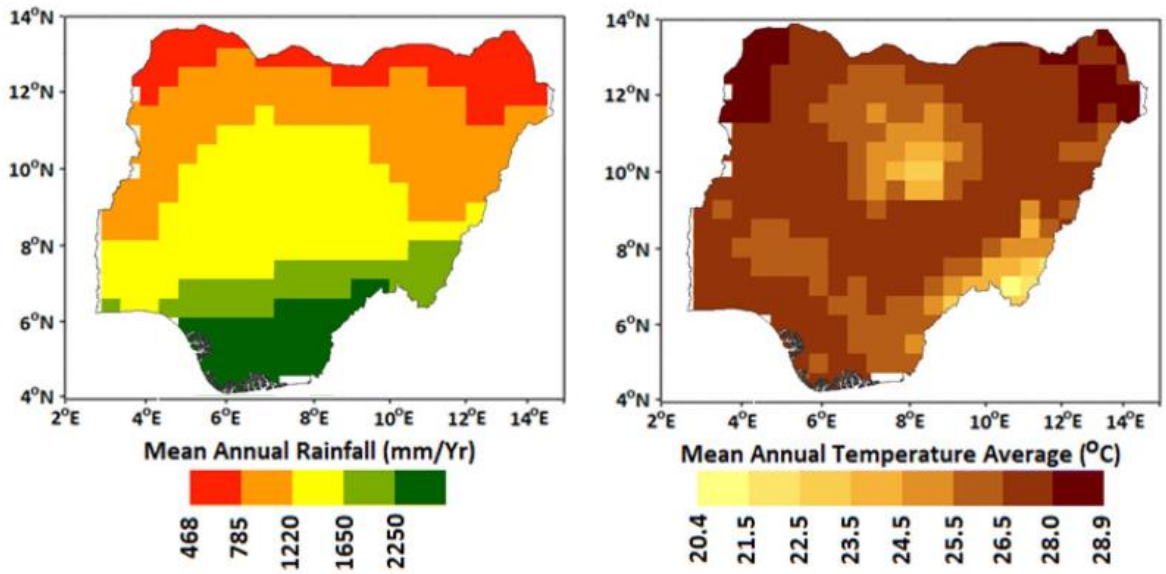


Figure 1.3: Annual Rainfall and Temperature Average across the Various Agroecological Zones of Nigeria (Shiru *et al*., 2020)

1.6.3 Soil, vegetation and hydrology

The MFCV of Nigeria is characterised by deltaic plain soils distributed across both wetland and upland areas (Elekwachi *et al*., 2021). The inland elevations of these soils range from 2 m to 4 m above mean sea level, with a low-lying coastline. It is a marine vegetation type found near the ocean, creeks, and estuaries. This marine vegetation type is typically found close to the ocean, creeks, and estuaries. They can be found in pure stands or mixtures with other vegetation, such as Nypa palm and other vegetative bluffs. The most obvious feature of the mangrove coastal forest vegetation is the stilt roots of *Rhizophora spp.,* which do not penetrate the ground but divide beneath the water surface to form an irregular thick-felt raft. Other notable plants of the coastal vegetation include raffia (*Raffia hookeri, Raffia sudanica*), oil palm (*Elaeis guineensis*), and coconuts (*Cocos nucifera*), which are found along the Barrier Lagoon coast. The white mangrove (*Avecinna nitida*) and red mangrove (*Rhizophora racemosa*) are the most conspicuous, ferns (*Acrosticum aureum*), and species of nypa avicennia palm (*Nypa fruticans*) are also abundant (Asuk *et al*., 2018). The Guinea Savanna is known for its alluvial soil due to the Rivers Niger and Benue. The region is characterised by diverse flora, with a mixture of tall grasses and trees, alongside shorter grasses and fewer trees in the northern part. In contrast, the central and eastern areas exhibit distinct montane vegetation (Adenle *et al*., 2020).

The soils of the SSEZ zone are generally regarded as low in fertility and productivity as they have a poorly developed a weak structure that deteriorates with cropping and compaction, making the vegetation dominated by thorn shrubs and grasses. Additionally, the region is home to various plant species, including Acacia, baobab, mango, orange, and Moringa. The soil quality is conducive to the cultivation of crops such as cereals (millet, rice, corn, sorghum, and maize) and legumes (soybeans and cowpea) (Macaulay, 2014).

1.6.4 Socioeconomic activities

Nigerian coastal communities engage in various economic activities, including logging, renting chainsaws, canoe carving, basket weaving, fish card weaving, fishing, trading, and sand collection. However, these activities have led to the unsustainable exploitation of mangrove forests for fuel, charcoal, and construction materials (Eleanya *et al*., 2015). Historically, these forests have served as a significant source of livelihood for households in the region, but they now face numerous challenges due to overexploitation and deforestation (Mafiana *et al*., 2022; Numbere and Maduike, 2022). The low-lying coastal region of Nigeria is particularly vulnerable to rising sea levels caused by climate change and various socioeconomic activities. In addition, intensive oil exploration and mining have further degraded mangrove forests (Onyena and Sam, 2020). Hazards such as rising sea levels and seawater intrusion into inland waters threaten the ecosystems and livelihoods that depend on them, including agriculture, fishing, and domestic and industrial activities. This situation may lead to the evacuation of some coastal towns, as residents are forced to relocate to safer, more inland locations (Elisha and Felix, 2021; Oloyede *et al*., 2022).

The Guinea Savanna, which covers almost half of Nigeria's landmass, is a biome characterised by a tropical climate and diverse plant and animal species. It is the country's principal food source, with most crops grown using rainfall and grazing resources for livestock (Obateru *et al*., 2024). Agriculture plays a key role in the lives of the people of the Guinea savanna, with a notable proportion of its rural population engaged in this activity, which is largely subsistence in nature and practiced on numerous small farm holdings (Adenle *et al*., 2020). This ecological zone is home to 25 percent of Nigeria's land surface area, supporting three-quarters of cattle production, approximately 75 percent of livestock production (goats and sheep), and virtually all the donkey, camel, and horse populations. The region's principal crops are major cereals, including cowpeas, groundnut, and cotton (Udo, 2023). The deterioration of the environment has led to an ecosystem decline, with a subsequent deterioration of the livelihoods and socio-economic activities of the population (Adenle *et al*., 2020). This trend can be attributed to unsustainable land use and climate stress.

The SSEZ of Nigeria, which is the northernmost region of the country, experiences a constant increase in livestock mortality, food shortages, and soil depletion due to persistent and extreme drought episodes (Atedhor and Atedhor, 2024). These episodes have resulted in many rivers and streams drying up, and lowering the water table (Eduvie and Oseke, 2021). This zone is the primary source of forage and grazing land, supporting the cultivation of cattle, donkeys, camels, and other domestic animals. Given the high level of poverty and the necessity for survival, calls have been made to ensure that ecosystem integrity is no longer compromised, which can only be achieved by implementing appropriate strategies (Nji and Balgah, 2019).

Nigeria is Africa's most populous country, with the SSEZ accounting for the largest population in the country (Figure 1.4). The largest population densities can be observed in the coastal and tropical rainforests of the country, particularly in the southern region, as shown in Figure 1.5, which depicts the uneven distribution of population across the country.

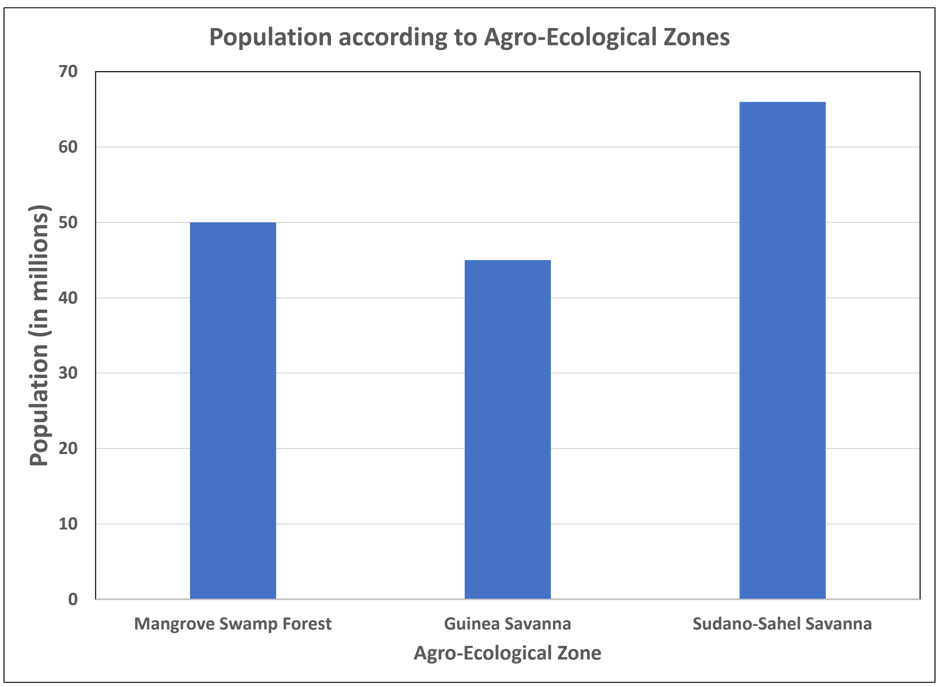


Figure 1.4: Estimated Population Across the Various Agro-Ecological Zones of Nigeria (Muhammad *et al*., 2015)

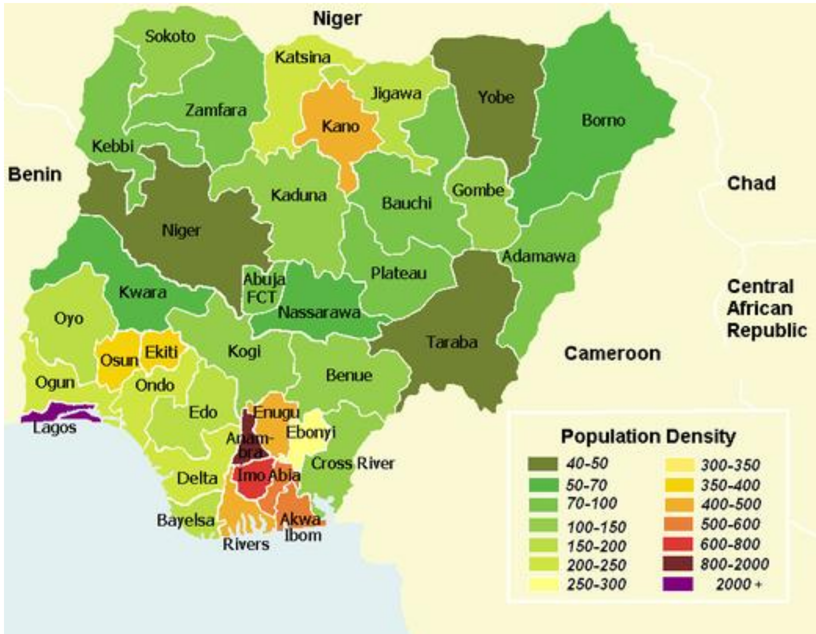


Figure 1.5: Map of Nigeria Showing the Population Density (Muhammad *et al.,* 2015)

1.7 Scope and Limitations

This study covers Nigeria, focusing on regions experiencing high rates of internal out-migration and in-migration. It examines the impact of environment and climate-induced changes on migration trends in Nigeria between 1993 and 2022. The selected temporal range is based on the observation that the migration of households from their places of origin due to the changing climate and environmental degradation became evident from the 1990s onwards and has been a recurrent situation until the present day (Li and Samimi, 2022; Wolde *et al*., 2023). Nevertheless, ten years (2014–2023) of available Normalised Difference Vegetation Index (NDVI) and Normalised Difference Built-up Index (NDBI) data from LANDSAT 8 were acquired for land degradation studies. The data for land degradation studies was extended to 2023 to determine the current situation when the field survey was carried out.

The lack of observed tidal gauge-recorded sea level rise data and the coarse resolution of long-term observations (1 per 10,618 km^2), as against the World Meteorological Organisation (WMO)'s recommended gauge density of 1 per 874 km^2 (Ngene and Obianigwe, 2018), was a challenge for this study. This necessitated the utilisation of gridded and reanalysis data as reliable alternative sources for climatic studies.

The lack of reliable primary migration data to study the patterns and impacts of internal migration in Nigeria is an enormous challenge. The most recent national census was undertaken in 2006, with current population estimates based on subjective projections. To study internal migration, accurate data from periodic and recent population censuses are necessary (Chanysheva *et al*., 2021). Based on these findings, local knowledge and perception studies were adopted to provide adequate information and insights into migration patterns. While these surveys offer valuable insights, the absence of direct migration data limits the potential for more precise empirical estimations of migration trends.

One of the most significant constraints in utilising remote sensing techniques in Nigeria, especially in coastal zones, is cloud cover (Uchegbulam *et al*., 2021). Nigeria's tropical climate is characterised by frequent and dense cloud formations, which present significant challenges in acquiring clear optical satellite images (Eludoyin *et al*., 2019). This impedes efforts to monitor changes in environmental factors over time, such as shoreline dynamics, land use patterns, and vegetation cover. Furthermore, the limited availability of images and the influence of cloud cover may result in temporal gaps in the data, thereby hindering the performance of consistent time-series analysis and potentially affecting the conclusions. To address these limitations, cloud-masking algorithms on the Google Earth Engine (GEE) platform were employed to detect and remove cloud-covered pixels from optical imagery, thereby enhancing the accuracy of the analysis. The dataset comprised 20 years (2003–2022) of available Moderate Resolution Imaging Spectroradiometer (MODIS) data, which was used for vegetation and drought monitoring due to its availability.

Integrating qualitative and quantitative data into nexus studies remains a significant challenge (Albrecht *et al*., 2018). The challenge presented by this study is based on the considerable discrepancy in the scale and level of detail between satellite-based indicators and perception-based data, as well as the necessity to comprehend the complex interdependencies between the various parameters. Although globally aggregated data employs standardised methods and metrics to ensure comparability across different locations, such uniformity may occasionally be at the expense of capturing local variations (Timans *et al*., 2019). Meanwhile, local or community-based research allows for customised methods that fit specific contextual circumstances.

During the field survey investigations, the respondents showed considerable reluctance and distrust due to their concerns about the scope of the information provided and their hesitancy to provide answers to the questions posed. The contributions of the field assistants, who also acted as translators, were invaluable in addressing this challenge.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Conceptual Review

This section of the study examines the definitions of the independent and dependent variables. The independent variables are the climate and ecological health indicators, including temperature, rainfall, sea level rise, and drought. The dependent variable is migration, a function of environmental and climate alterations. This section, therefore, considers a logical way of conceptualising the climatic and ecological factors that may be responsible for internal migration.

2.1.1 The concept of the environment

The term "environment" encompasses the living and non-living components of the surrounding ecosystem. These interactions may influence an individual's growth, health, and overall development. (Ayeni and Kambizi, 2013). It is also known as the physical, economic, social, and cultural factors, processes, and influences that impact a person's development and behaviour, emphasising the contribution of environmental factors in determining human experiences and interactions (Carter, 2017). The natural and built-up components of the environment can be conceptualised as a complex system. The built environment is the infrastructure and buildings comprising the human environment. In contrast, the natural environment includes air, water, soil, and climate elements. This is essential to human sustainability, health, and general well-being (Araya-León *et al*., 2023).

The study of the environment considers issues such as geography, climate, water bodies, and land resources. The physical environment depends on several factors, including desertification, deforestation, flooding, and climate change. On the other hand, the biological aspect of the environment refers to living systems within which humans exist (such as biodiversity), which play essential roles in food security and agriculture (Benabou *et al*., 2022). The physical and biological environments that shape the present world exert influential impacts on the social aspect of human endeavours, which define and shape human cultural, political, and governance policies, institutional frameworks, and socio-economic activities (Peng and Jia, 2023).

2.1.1.1 The concept of ecological health (drought)

Ecological health refers to the state or condition of an ecosystem, denoting the capacity to support different forms of life and to maintain ecological processes, including air, water, and soil quality, availability of natural resources, and green spaces (Müller *et al*., 2020). As a crucial component of the environment, ecological health is impacted by resilience, biodiversity, ecosystem services, and ecosystem functioning (Hernández-Blanco *et al*., 2022). Environmental stressors like drought affect the ecological health of a location or region by impacting its vegetation and water resources.

Droughts are periods of water shortages and continuous and persistent anomalies in rainfall that can result in economic losses when they stretch throughout a season or more, with the inability to meet human activities and environmental demands (Orimoloye *et al*., 2022). It is one of the most destructive catastrophes on earth and may occur almost anywhere around the globe. The reduction in rainfall over an extended period (Ndayiragije and Li, 2022) has devastating effects on humans, water resources, the environment, water resources, and agriculture (Orimoloye *et al*., 2022; Pourzand and Noy, 2022). Drought stress reduces plant growth and productivity, resulting in decreased crop yields and increased food insecurity. This occurrence is widespread within drylands (arid, semi-arid, and dry sub-humid areas) all over the world, including the Sudan-Sahelian region of Nigeria (SSRN) (Descroix *et al*., 2024). These arid regions typically exhibit a negative water balance annually, indicating that the rate of water evaporation exceeds precipitation during the year. As precipitation levels decline below average, water resources are diminished, and the persistence of this condition over an extended period in a specific location results in the onset of drought (Haile *et al*., 2020).

Following the drought events in the SSRN during the 1970s and early 1980s, several attempts have been made to elucidate how humans and the natural environment have been influenced and adapted to the region's evolving climate and weather patterns (Lu *et al*., 2024). Nevertheless, the extent to which these factors exert influence and the existence of their impact on human populations and the natural environment remain subjects of debate.

2.1.2 The concept of the climate system

The climate system is essential for understanding long-term patterns and variations in atmospheric conditions, which are features of different parts of the earth. Weather describes changes in the atmosphere occurring over a short period, whereas climate refers to the average weather that lasts around 30 years or more (Abbass *et al*., 2022). Several natural factors, such as latitude, altitude, proximity to water bodies, ocean currents, topography, and vegetation, all shape a location's climates. Anthropogenic factors such as urbanisation, deforestation and greenhouse gas emissions can also alter an area's climate.

Nigeria's agricultural practice is predominantly rain-fed, and rely on precipitation for irrigation. The unpredictability of the climate, coupled with the prevalence of extreme weather events such as droughts and floods, presents a significant challenge for farmers in executing adequate planning (Prince *et al*., 2023), raising substantial constraints on agricultural productivity, given that these phenomena cannot be predicted by farmers, making it very difficult for them to prepare ahead (Awolala *et al*., 2023). The agricultural sector plays a pivotal role in national food security, accounting for most of the total national food consumption requirement (Osabohien *et al*., 2018). Forest zones are associated with crops like cocoa, oil palm, and rubber, while the savannah region is known for cultivating cereals, legumes, and livestock. Therefore, it is crucial to understand climate dynamics to develop effective strategies to address the challenges associated with variations and changes. These challenges have far-reaching implications for ecosystems, human health, agriculture, and overall societal well-being.

2.1.2.1 Decline in rainfall amount and high rainfall variability

Rainfall is a pivotal component of the climate system that exerts a huge influence on the availability of water, the growth of vegetation, and the productivity of agriculture. Rainfall is influenced by several factors, including global climate change, regional atmospheric dynamics and local environmental conditions. A downward trend in rainfall has been observed in northern and southern Nigeria since the early 1970s, with anthropogenic activities identified as contributing factors (Oloruntade *et al*., 2017; Dike *et al*., 2020). This development can have devastating effects on rainfall-dependent agriculture, affecting the high dependence on survival of a greater percentage of the nation's population. In addition, the shift in the onset/cessation dates of the rainy season has changed tremendously (Fuwape and Ogunjo, 2018), which has posed challenges to farmers in predicting the actual dates of planting and harvesting, leading to poor agricultural yields, food insecurity, and economic instability at agricultural homesteads (Wahab and Popoola, 2018). The alteration of rainfall patterns has resulted in a notable decline in water availability in Nigeria, which has had a detrimental impact on agricultural production (Ogunrayi *et al*., 2016) and contributed to desertification at the northern fringes of the country (Olagunju, 2015). Meanwhile, the increased intensity of rainfall events has led to more frequent and severe flooding, especially due to poor drainage systems and increased impervious surfaces, which are consequences of urbanisation (Ologunorisa *et al*., 2022; Toka, 2022).

2.1.2.2 Increase in temperature

In line with global trends resulting from increasing greenhouse gas emissions, temperature warming trends have been established in Nigeria (Abatan *et al*., 2016), with reported increasing temperatures of between 0.14°C and 0.42 °C/decade in some locations, leading to increased evapotranspiration, reduced soil moisture, and drought (Shiru *et al*., 2018). The temperature rise is also responsible for heat stress and the reduction of livestock productivity, as depicted by altered feed intake, growth rate, and reproductive performance, leading to threatened food security, higher food prices, and economic losses (Madziga, 2021; Oke *et al*., 2021). The increase in temperature invariably has significant effects on Nigeria's social, environmental, agricultural, and economic sectors (Shiru *et al*., 2020), contributing notably to rural-urban migration and displacement.

2.1.2.3 Sea level rise

The term "sea-level rise" refers to a global, long-term, continuous rise in the mean level of the Earth's oceans. This is primarily caused by the melting of terrestrial ice sheets and glaciers and the heat-related expansion of ocean water due to global warming (Haasnoot *et al*., 2021), resulting in a global mean sea level increase of 20 cm from 1901 to 2018 (Khojasteh *et al*., 2023). The global mean sea level increased from 0.15 m to 0.25 m between 1901 and 2018, rising by 3.3 mm/yr, based on high-precision altimeter satellites, producing a total global increase of about 8 cm. The acceleration of this rate can be attributed to the continuous warming of the oceans and the melting of land ice (Hamlington *et al*., 2020; Cazenave and Moreira, 2022). Projections of exponential increase from altimetry studies have indicated great threats to coastal regions globally, at about 0.5 m to 2 m by 2100 (Taherkhani *et al*., 2020; Gower and Barale, 2024).

Meanwhile, the sea-level rise rate along the West African Gulf of Guinea coastline has exceeded the global mean of 3.64 mm/year. According to projections, there will be an increase from 0.55 m to 1.1 m at the end of the 21st century (Nyadzi *et al*., 2021). Nigeria is not exempted from the risks posed by the rising sea levels, with The Niger Delta, a very dense and ecologically relevant region of Nigeria, being a particularly vulnerable region (Dike *et al*., 2020). A slight increase in sea level would enhance flooding in low-lying regions and communities, putting infrastructure and farmlands at risk while contributing to the erosion of mangrove and other coastal habitats crucial to biodiversity and fishery resources (Benson, 2020). Nigerian coastal communities continue to experience alarming rates of coastal erosion, up to several meters per year, negatively impacting the livelihoods of fishing and farming communities and leading to the displacement of several households (Elisha and Felix, 2021).

2.1.3 Migration as the dependent variable

The term "migration" describes the relocation of individuals or groups from one location to another, whether within the same country or to another country entirely, to establish a long-term or permanent residence (Clark, 2020). Migration may be classified as internal (occurring within a country) or international (crossing national borders). It can also be referred to as emigration (movement out of a country) or immigration (movement into a country) (Toney and Bailey, 2014). Migration is driven by several factors, such as economic (better job opportunities, higher incomes, escaping poverty, improved standard of living) (Cummings *et al*., 2022; Czaika and Reinprecht, 2022), Socio-political (escaping war, conflict, insecurity; political instability; reuniting with family and friends; marriage; adventure) (Chan *et al*., 2022), and environmental (natural disasters, climate change) (Islam, 2018).

Droughts and floods are environmental changes that may influence people to migrate. For instance, the intensification of desertification in the Sahel region has prompted a notable shift from rural to urban areas, as individuals seek enhanced socioeconomic prospects (Naz and Saleem, 2024). Rural-to-urban migration, which is the most predominant type of internal migration, is frequently motivated by the pursuit of enhanced economic prospects and an improved quality of life (Lagakos, 2020). This form of migration often has significant implications for the location left by migrants (origin) and the location moved to (destination) (Castelli, 2018).

2.1.4 Linking independent variables to dependent variables

The environment and climate are the independent variables that drive migration. Recently, some studies have demonstrated the influence of environmental and climatic factors on human migration (Hoffmann *et al*., 2020; Borderon *et al*., 2021; Daoust and Selby, 2024). Drought, resulting from changes in the climate or human activities, can lead to water scarcity and loss of agricultural products and, invariably, to migration between communities (Hermans and McLeman, 2021; Ceola *et al*., 2023; Smirnov *et al*., 2023). An increase in sea level can lead to surface runoffs, flooding, and loss of habitats, significantly affecting coastal areas and eventually leading to migration (Duijndam *et al*., 2022).

The relationship between the environment, climate, and migration is a complex and multifaceted phenomenon. Identifying the causes of human migration is a complex and challenging task. This is particularly evident when considering the potential costs and risks associated with migration as a strategy for adapting to environmental change. These risks and costs are influenced by various factors, including the search for food security, resources, improved livelihoods, and the desire to avoid risks (Borderon *et al*., 2021). Scholars of migration have held divergent views because of the differing theoretical framings between those who employ quantitative analysis and those who adopt an anthropological approach (Brüning and Piguet, 2018; Borderon *et al*., 2021; Piguet, 2022). The impacts of the changing climate and environment, including temperature rise, high rainfall variability, increased rainfall intensity, drought, sea level rise, and flooding, have been identified as environmental and climate-induced factors that drive migration (Rigaud *et al*., 2021). This establishes a relationship between the independent variables (environment and climate-induced drivers) and the dependent variable (migration), implying that migration depends on climatic and environmental factors, such as temperature rise, drought, sea level rise, and rainfall changes (Figure 2.1). These parameters disrupt livelihoods, particularly in agriculture-dependent rural areas, leading to migration, which may have benefits (improved economy) and challenges (conflicts and insecurity) (Adedokun and Karzanova, 2019; Kamta *et al*., 2020).

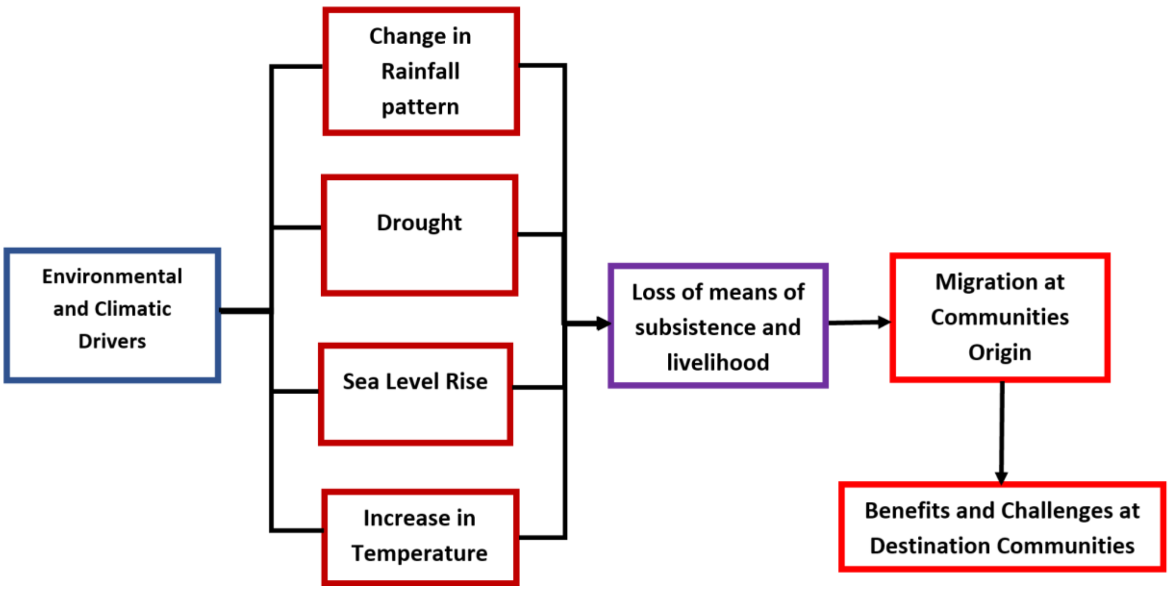


Figure 2.1: Literature-based Conceptual Model Showing the Link Between Environment/Climate Factors and Migration

Source: Author (2024)

2.2 Theoretical Framework

2.2.1 Drivers of migration

Migration has been identified as a common strategy households employ to enhance their livelihoods and reinforce social resilience in response to economic, social, demographic, political, and environmental conditions (Figure 2.2). These conditions can act as push or pull factors for migration among individuals or households. Economic factors include seeking better job opportunities and higher living standards, while social factors may include family, cultural ties, or education (Simpson, 2022). Demographic factors such as population size, age, and gender may influence migration decisions (Simpson, 2022). Meanwhile, environmental/factors such as floods, droughts, natural disasters, and sea level rise can affect the livelihoods of individuals or households, thereby influencing their migration (Hunter and Nawrotzki, 2016).

Therefore, it is not surprising to encounter difficulties in determining how migration is driven because these factors still need some clarification. Although an overview of environmental and climate-induced migration has been generalised, empirical studies that specifically quantify the role of climatic and ecological health indicators in influencing migration decisions are lacking, particularly in Nigeria. Therefore, this research study makes a necessary contribution to the field.

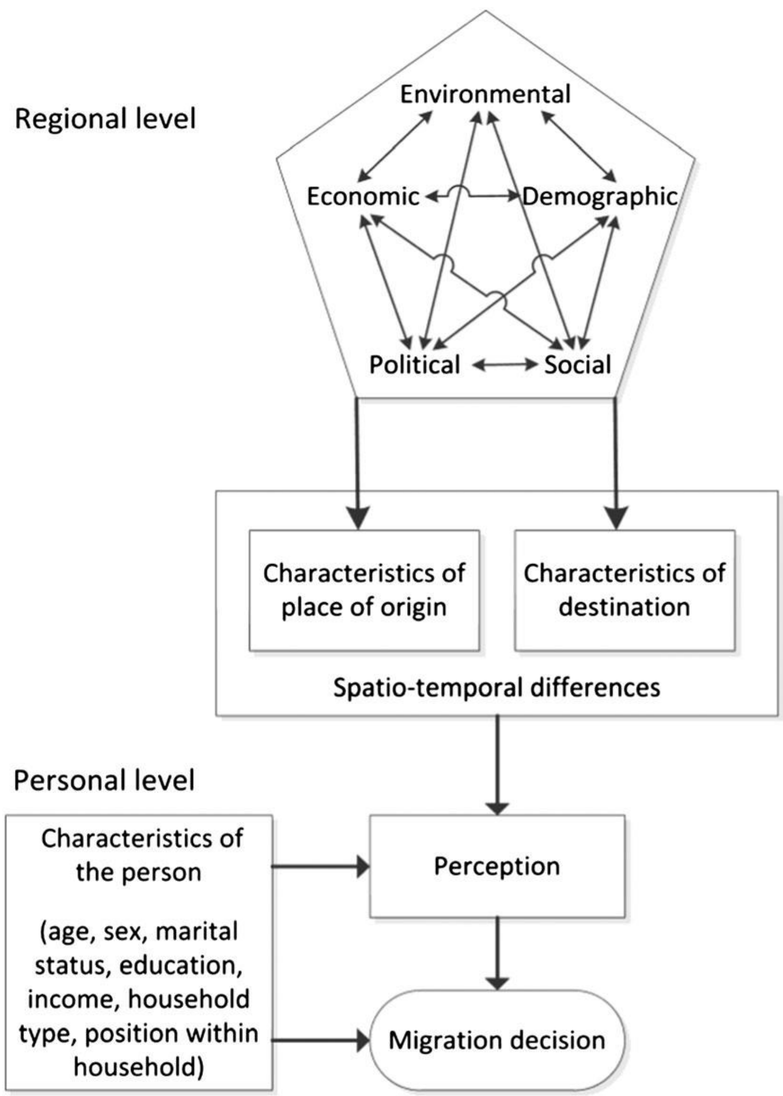


Figure 2.2: Theoretical Framework of Migration and its Drivers (Neumann and Hermans, 2017)

2.2.2 Theories of climate and environment

Theories of the climate and environment explain humans' interaction with the environment anpan and d climate and how humans modify and respond to changes around them. These theories are critical for providing the framework that underpins the study, particularly when investigating how climate and the environment act as migration drivers.

These theories provide insights into environmental factors to explain how the environment and climate lead to migration, thereby establishing a clear and explicit link and enhancing the depth of the analysis. Thus, it is essential to establish this foundation to provide a robust basis for the research question and the study's findings.

2.2.2.1 Ecological theory

The ecological theory studies the interactions of different organisms (including humans) within an ecological system while highlighting their dynamic processes and patterns. This postulation views the environment as an intricate system comprising various factors that play major roles in the ecosystem regarding resource utilisation, energy flow and nutrient cycling (Ettekal and Mahoney, 2017). This theory is important for studying environmental degradation dynamics and understanding how human settlements are structured and distributed spatially across different environments.

2.2.2.2 Theory of environmental determinism

According to this theory, the physical environment, such as the climate, shapes human societies and cultures (Fekadu, 2014). In other words, it explains how geographic factors such as temperature, precipitation, and topography influence societies, their institutions, culture, politics, economy and behaviours (Johnston, 2017). The theory of environmental determinism comprises climatic determinism, geographical impacts, and ecological factors (Jónsson, 2010). However, this theory has received recent criticisms due to its perceived determinism and its tendency to reduce complex phenomena to simple, underlying causes.

2.2.2.3 Geographical theory

This theory highlights the role of the Earth's spherical shape and rotation in affecting the distribution of solar radiation. According to this theory, an area's climatic condition can be determined by three factors: latitude (warmer temperature toward the equator due to more direct sunlight while cooler toward poles due to less amount), altitude/height (higher elevations experience colder temperatures due to the lower atmospheric pressure and reduced solar radiation), and continentality (large water bodies influence seasonal temperature differences by absorbing and releasing heat more slowly than other surface materials) (Coelho *et al*., 2023).

2.2.2.4 Anthropogenic theory

This theory illustrates human activities that significantly affect the natural environment and emphasises how human-induced changes disrupt ecological and geological processes. The Anthropocene concept is central to understanding this theory. The Anthropocene is a proposed epoch in the Earth's geological history that reflects human activity's impact on the planet's ecosystems and geology (Cook *et al*., 2022). Human activities, including deforestation, urbanisation, industrialisation and the increased concentration of greenhouse gases such as carbon dioxide in the atmosphere, are the primary drivers of climate change. This has led to global warming. (Kabir *et al*., 2023). Furthermore, this theory highlights the intimate connection between humans and their environments, highlighting the need to reconsider how societies utilise nature and resources on Earth. It is important to understand the impacts of these causes on the environment and develop sustainable approaches to minimise the damage they cause while maintaining ecological resilience.

2.2.3 Migration theories

2.2.3.1 Push-pull theory

The field of migration studies requires further theoretical development and definition. It is almost impossible to frame an all-inclusive migration theory that incorporates the diverse contributions of various disciplines in this context (De Haas, 2021). Lee (1966) developed a general migration approach and established a "push-pull" theory. This theory posits that migration is driven by differences in spatial, social, and economic conditions, prompting individuals to relocate from less attractive to attractive areas (Mohamed and Abdul-Talib, 2020). The four categories of "push-pull" factors that induce migration were as follows:

i. Features of the area of origin
ii. Nature of the destination area
iii. Interfering obstacles to migration
iv. Personal factors that may influence the decision-making process

The "push factor" in Lee's concept refers to the challenges an individual may experience and/or perceive in their initial location. This may include perceived unfavourable political, religious, economic or socioeconomic situations (Rosmilawati and Sofyan, 2021). Meanwhile, the term "pull factor" describes the various positive prospective outlooks that potential emigrants may have regarding their destination. This may include political and economic stability, opportunities, and better socioeconomic facilities (Kumpikaitė-Valiūnienė *et al*., 2021). The push-and-pull concept, therefore, describes the motivation behind individuals' migration decisions. However, this approach has its limitations because the ability to differentiate between these push-and-pull factors may be difficult from a scientific standpoint. For example, wage differentials can be considered in two distinct ways: low wages can be viewed as a push factor, whereas high wages can be regarded as a pull factor (Fan *et al*., 2019). Other criticisms of this theory include its static nature, lack of structural frameworks, over-generalisation and neglect of the multifaceted nature of migration (De Haas, 2021). This can also be said of other migration theories, as personal decisions are often based on various complex and interrelated factors.

2.2.3.2 Neoclassical migration theory

The neoclassical theory of migration is an economic extension of Lee (1966) concept, particularly in the context of the discrepancy in the demand and supply of labour between different locations. Neoclassical theory posits that at the macro level, wage differences drive individuals to relocate from regions or countries with low wages to those with higher wages. This difference can be attributed to the demand and supply of labour in specific regions. The theory emphasises the differences in payment and employment terms observed between different locations and the costs individuals incur when migrating. The magnitude of these differentials may determine the extent or magnitude of migration (Karpestam and Andersson, 2013).

On the other hand, the neoclassical theory also considers the microeconomic model based on the decisions made by individuals to emigrate, not just based on wages, but also the tentative venture in human capital, meaning that destinations will be selected based on the highest investment returns (Fischer *et al*., 2021). Consequently, prospective migrants will evaluate the psychological and financial implications before deciding to migrate.

2.2.3.3 New economics of labour migration

The New Economics of Labour Migration theory posits that the decision to migrate is a household strategy, whereby individuals relocate to provide support to the larger family or economic unit, either of their own free will or at the request of the household or family to obtain remittances and thereby diversify their income sources (Seidu *et al*., 2022). Not only will income be maximised, but households will be able to respond to market failures and overcome barriers to capital and credit, thereby minimising risks and diversifying their incomes (Weeraratne, 2022). This theory provides a framework for understanding the role played by international emigrants in developing domestic infrastructure in West Africa. It posits that emigrants with access to new financial, social, and cultural capital can leverage these resources to contribute to the growth of their destination countries. Therefore, it is considered a risk reduction strategy and a means of adaptation.

2.2.3.4 Mobility transition theory

This theory, initially proposed by Zelinsky (1971), posits that migration is a consequence of, and a contributing factor to the economic and social transformations that come with modernisation. It asserts that the migration of individuals and groups serves to rectify socioeconomic development and economic imbalances between regions due to uneven economic growth. Zelinsky's theory suggests that migration patterns and rates are closely associated with the stage of modernisation (for instance, industrialisation) and demographic factors (such as high fertility rates). This theory links together the various elements of mobility and incorporates existing processes that have characterised the historical trajectory of many societies (Mehdizadeh *et al*., 2022). Mobility transition identifies patterns and regularities in how people move around and where they live. It also identifies the five distinctive phases that constitute an irreversible progression of stages:

i. Phase I (Pre-modern Traditional): This phase encompasses minimal residential migration and restricted circulation permitted by customary practice;
ii. Phase II (Early Transitional): This phase is characterised by a significant movement of people from rural to urban areas and from the countryside to the borders of newly established colonies. There is also a notable outflow of emigrants, alongside an increase in circulation and the arrival of a small but noteworthy number of skilled professionals;
iii. Phase III (Late Transitional): This phenomenon is characterised by a gradual yet significant rural-urban shift. In this case, there is an increase in the volume and complexity of circulation, a reduction in the number of people moving to areas that are undergoing colonisation, and a reduction in the number of people emigrating.
iv. Phase IV (Advanced): In this phase, residential mobility is leveled off. The movement of people from rural to urban areas is further reduced. There is vigorous movement within and between urban areas, while the settlement frontier remains stagnant or retreating. There is significant net immigration of unskilled and semi-skilled workers from relatively underdeveloped lands. There is significant international mobility among skilled professionals, with a corresponding vigorous circulation, particularly among those engaged in economic and leisure activities;
v. Phase V (Future Super-advanced): This illustrates a significant decline in residential mobility and specific forms of circulation resulting from the advancement of communication and delivery systems. In addition, accelerated circulation has

occurred, and new forms may emerge. Most residential mobility occurs within and between urban areas, and intense political control dominates internal and international movements.

2.2.3.5 The aspiration and ability theory

While scholars have previously posited theories regarding migration, recent studies have led to the formulation of more parsimonious yet definitive approaches to migration studies. “Decision-making” or “choice” in the context of migration was expanded upon by Carling (2002), who introduced the theoretical pair of aspiration and capability. This was done to elucidate the prevalence of what was designated as 'involuntary immobility', describing the aspiration to migrate but the inability to do so. In the Aspiration and Ability model, "migration aspiration" is a belief that migration is preferable to non-migration. The extent to which this aspiration is held can vary considerably, as can the balance between the perception of choice and coercion in the decision to migrate (Carling, 2002). This is further illustrated in Figure 2.3, where the broken lines indicate the fluid boundary of migration aspirations. While some individuals can migrate, others are unable to do so and can be divided into two categories: involuntary non-migrants, who desire to migrate but lack the necessary resources, and voluntary non-migrants, who choose to remain in their current location due to a belief that remaining is preferable to migration.

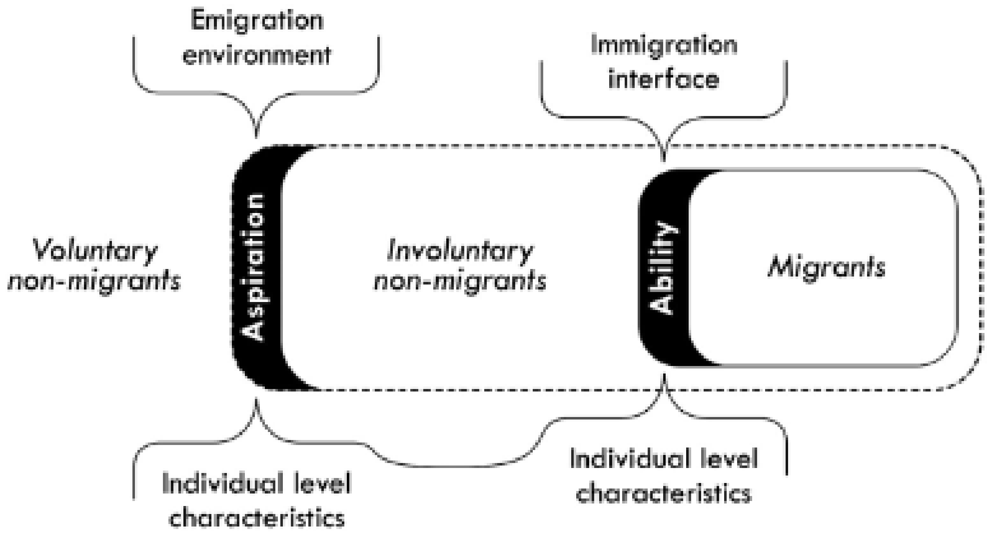


Figure 2.3: The Aspiration/Ability Model (Carling, 2002)

This has prompted further research to differentiate between migration intentions and the actual capacity to do so. The concept of acquiescent immobility has been employed to underscore that not all economically disadvantaged individuals aspire to migrate, with a considerable proportion having never contemplated doing so (Di Cristo and Akwei, 2023). The relationship between aspiration and ability has become increasingly dynamic and multifaceted (Debray *et al*., 2023). Several studies have attempted to integrate how humans interact with the natural environment with factors influencing migration, including the abilities and aspirations of migrants. This approach has been considered to account for the cultural aspects of natural resource utilisation and the decision-making processes involved in migration (Wiederkehr *et al*., 2019, Hermans *et al*., 2023), resulting in a more accurate reflection of the reality experienced by people on the ground. This will facilitate the formulation of suitable legislative and administrative measures to enhance migration and disaster management. Abolga (2022) also posited that the aspiration and ability model is a two-stage process in making migration choices in West Africa. While migration aspiration is relatively certain, the ability to do so is highly uncertain.

2.2.3.6 Need for environment/climate-migration theory

Despite the established theories on environment and climate-induced migration, there is a growing consensus that more adequate studies are required (Hoffmann *et al*., 2020). Environmental and climatic factors should be given prominence when studying migration theories to establish links between climate and migration, and explain trends to make decisive predictions (Brettell and Hollifield, 2022). For example, the push-and-pull theory can be reflected in the impact of climatic variables, such as extreme temperatures or high rainfall variability, to make migrants seek more favourable locations elsewhere. The challenge in defining this situation is in the ability to determining the extent of influence or importance of these factors. The environment/climate-migration theory will incorporate the neoclassical theory and push-pull theory, amongst others, concerning the changing climate, which is beginning to have more influence on the economic, demographic, social, political, and environmental conditions of regions (de Sherbinin *et al*., 2022).

To examine the potential interconnections between the environment, climate and migration over time, social scientists have facilitated scientific endeavours to investigate the complicated nexus between these three phenomena, which remains challenging due to their complex and multifaceted nature. While some individuals may leave their homes because of conflict or poverty, others do so under conditions of peace, political stability, and development. Meanwhile, a significant rise in applications from climate refugees due to rising temperatures in developing countries has been predicted (Cattaneo and Peri, 2016; Missirian and Schlenker, 2017). In contrast to the assumption of independent action, climate and environmental factors exert influence through the various drivers of migration, resulting in a multifaceted set of social, political, economic, and environmental factors that drive human mobility (Rigaud *et al*., 2018; Van Hear *et al*., 2020). Several processes and events highlight the impact of the environment and climate on human migration. These include rising sea levels, salinisation of agricultural land, desertification, and growing water scarcity. In addition, a growing body of evidence suggests that climate events such as flooding and storms induce human migration (Rosengärtner *et al*., 2023). Considering the mounting interest in the connection between environment, climate and migration, there is a potential need to develop a theory to explain this relationship. However, this may prove to be a challenging undertaking.

2.3 Examples from other Regions/Countries

While conducting a systematic review to assess global trends and gaps in climate-induced migration research, Ghosh and Orchiston (2022) identified key areas with limited evidence and highlighted the need for improved global datasets. While the review provides a valuable overview of global research trends, it is limited by excluding more recent studies and lacking empirical data. This research offers a global perspective that can inform the current study by identifying gaps and areas for further exploration.

By systematically reviewing the cumulative effects of various climate-related disasters on migration patterns within the Global South, Almulhim *et al*. (2024) identified various climate stressors, such as temperature rise, water stress, floods, and sea-level rise, as factors of population displacement (internally and across borders). They posited that these factors interact and contribute to migration. The study offered a broad overview of climate-induced migration through various sources but did not consider local studies that are not well represented in major databases, potentially overlooking specific regional dynamics. However, the study provides relevant insights into how desertification, flooding, and scarce resources drive migration patterns. This is crucial for a more comprehensive grasp of the influence of climate change on displacement, while also underscoring the necessity for further investigation into the interplay between diverse climate elements and their collective impact on migration patterns. Ahmed *et al*. (2024) used a literature review methodology by synthesising empirical studies, case studies, and theoretical frameworks that show how climate change drives migration in South Asia. Key environmental factors like rising temperature, fluctuating rainfall patterns, and increased weather events heighten socioeconomic vulnerability to temporary or permanent migration. As previous studies have indicated, migration is a coping strategy for households with reduced agricultural productivity and livelihood disruption. They emphasised the need to include migration in climate change adaptation policies for the betterment of communities affected.

The relationship between climatic and socioeconomic parameters and the migration of people from southwest Germany to North America during the 19th century was analysed. It was found that climate was a significant factor influencing agricultural production, affecting food prices and, in turn, exerting an indirect influence on out-migration (Erfurt *et al*., 2019). The period between 1816 and 1817 appears to have been the most climatically influenced, with significant changes in temperature and precipitation. These changes resulted in climatic stressors such as cold winters, droughts, rainy seasons, and summer heat, which indirectly had some influence on migration patterns.

Thorn *et al*. (2023) empirically reviewed climate migration based on household surveys, informant interviews, and secondary sources between 1990 and 2020 in Namibia. They established that climate change, particularly through drought and flood events, is one of the main drivers of migration due to rising socioeconomic vulnerability. The findings of this study indicate that migration is a coping mechanism and adaptation strategy against climate variability. The trade-offs between reduced crop loss, increased heat stress, and insecure tenure as the attendant consequences are evidence of this. It was recommended that appropriate policy measures should be implemented to address the underlying causes of climate-induced migration and provide support for vulnerable populations.

The mixed-method study by Naz and Saleem (2024) examined the Sahel region of Africa, positing that vulnerabilities arising from climate change, increase the risk of conflict and forced migration. This study analysed the interconnections between climate change, conflict and migration. Nevertheless, the narrow scope of the study, with a focus on a limited number of case studies, may restrict the range of contexts and applications to which it can be applied. This research study is relevant to Nigeria because of its similar climate-induced challenges and migration patterns. It therefore offers important insights into the broader impacts of climate-driven migration.

In their review of climate-induced migration in West Africa, Teye and Nikoi (2022) synthesised the empirical findings and theoretical frameworks concerning the drivers of migration induced by climate change in the region. Key environmental factors, such as increases in temperature, rainfall fluctuations, and flooding, significantly influence the migration patterns that contribute to increasing socioeconomic vulnerability and seasonal and permanent mobility. This study's findings indicated that households employ migration as a coping strategy and thus recommended that migration be incorporated into adaptation policies related to climate change. However, the review was mainly limited to empirical evidence, which limits the conclusions. The study is relevant as it provides insightful information on household migration strategies in West Africa. Nevertheless, it highlights the need for research and policy formulation to improve climate-induced migration management. This will facilitate a better understanding of the mechanisms through which climate change drives migration. West Africa is considered one of the most susceptible regions to climate change and variability impacts. This is due to its extensive semi-arid geography and reliance on rain-fed agriculture. Temperature increases and alterations in rainfall patterns influence livelihoods, food security, and economic and governance stability (Sultan and Gaetani, 2016).

During the 1970s and 1980s, the West African Sahel experienced a notable reduction in precipitation and severe droughts. This resulted in widespread famine and population displacement (Adaawen *et al*., 2019). Like Nigeria, Ghana's agricultural sector is predominantly rain-fed, and its success depends on the annual rainfall patterns. The impact of climate variability on food security is significant, with a detrimental effect on the sector's performance observed annually (Yeleliere *et al*., 2023), due to the changes in the onset and cessation dates of the rainy season (Kumi *et al*., 2023). In addition, Lenshie *et al*. (2022) provided a significant regional perspective by qualitatively studying the Sahel region of West Africa. They argued that climate change intensifies existing vulnerabilities and conflicts, causing increased migration. The strength of this study lies in its thorough analysis of the geopolitical dimensions of climate-induced migration, which offers insights into regional stability. However, the focus on broader geopolitical issues may overlook individual migrant experiences and local dynamics. This study contributes to the existing research by illustrating how climate change can lead to conflict and displacement, which is relevant to understanding similar dynamics in Nigeria. This underscores the need to research the role of specific climatic factors in migration decisions.

2.4 Review of Related Studies

Several empirical studies have demonstrated the link between the changing environment/climate and human migration. This review presents an overview of key studies to highlight the contributions, strengths, limitations, and relevance of these studies in the current research on environment and climate-induced migration. Igwe (2020) assessed the relationship between climate-induced migration, land conflicts, and security challenges in Nigeria by combining surveys, interviews, and secondary data analysis. This study considered how climate change, especially changes in precipitation patterns, drives people to migrate, intensifies competition for land and resources, and causes conflicts. His findings show that climate-induced migration contributes significantly to land conflicts, particularly among vulnerable households, and intensifies security risks at both local and national levels. This study highlights the need for effective adaptation policies to address the root causes of migration and mitigate associated conflicts and security threats.

In a mixed-method approach conducted in Northern Nigeria, Ologeh *et al.* (2021) established the influence of climate change on farmers' migration decisions. Their findings showed that climate-related challenges, such as changes in rainfall patterns and increased temperatures, influence farmers to migrate. A significant strength of this research lies in its focus on local perceptions and socioeconomic contexts, thereby enhancing the understanding of the factors that influence migration. Conversely, a limitation of the study is its absence of empirical data, which limits the evaluation of the effects on migrants and their host communities. While investigating the impact of climate change and migration on rural entrepreneurs in

Nigeria, with particular attention to gender. Akinbami (2021) used a qualitative approach, sourced from in-depth interviews and focus group discussions across four different vegetation zones to establish climate change as a key driver of migration, with a significant effect on rural entrepreneurship. He further stated that men and women respond differently due to sociocultural factors and family responsibilities. In addition, migration disrupts local economies and social structures, often negatively impacting entrepreneurial development in rural areas.

Olagunju *et al*. (2021) conducted a qualitative study in Nigeria to examine how environmental degradation, worsened by climate change, has contributed to human displacement and social conflict. This study highlights interrelationships among climate change, environmental degradation, and migration patterns. This study's strength lies in the detailed explanation of the mechanisms through which environmental drivers of displacement and conflict are caused. However, the reliance of this study on qualitative data lacking significant empirical support limits its ability to generalise its findings in different contexts. The current study is relevant to ongoing research as it provides basic knowledge regarding how climate change influences migration in Nigeria and other human activities. Similarly, Madu and Nwankwo (2021) presented an empirical analysis of the spatial relationship between climate change and farmer-herder conflict vulnerabilities in Nigeria, using a climate security vulnerability model and data from secondary sources. Their spatial analysis revealed that while climate change significantly influences farmer-herder conflicts, the relationship is complex. Surprisingly, regions more vulnerable to climate change experience fewer conflicts, affirming that migration patterns and identity dynamics also play critical roles. The findings identify Benue State in the Middle Belt as a conflict hotspot, as climate change drives herders' southward migration due to worsening northern environmental conditions.

Ofuoku and Okompu (2022) expanded the understanding of climate change-induced migration patterns among agricultural households in Delta State, Nigeria, by combining survey data and a mental map to capture farmers' perceptions. They highlighted migration as a critical adaptation strategy, demonstrating that climate-induced changes in rainfall variability and extreme weather events induce migration, leading to improved access to agricultural services, remittances, and social networks. This increases the adaptive capacity of the migrating family, improving food security and reducing vulnerability to climate change. However, the report does not include the long-term impacts of migration. In empirically assessing flood risk perceptions on future migration intentions in Lagos, Ekoh *et al*. (2022) used a mixed-method approach to examine the dimensions of flood risk perception. The findings revealed that the residents' historical experiences and proximity to flooded regions influence their perceived risk, which is positively correlated with migration intentions. The study emphasises the necessity of employing diverse measures to assess flood risk perceptions to inform targeted interventions and communication strategies.

While empirically analysing the impact of land use and land cover changes on migration and food security in the North Central Region of Nigeria, Okeleye *et al*. (2023) used multispectral satellite remote sensing data from Landsat spanning 1990, 2000, 2013, and 2020, including net migration data, household surveys, focus group discussions, and expert interviews to affirm that migration and food security are significantly influenced by alterations in land use and land cover (LULC). Meanwhile, Ekoh *et al*. (2023) explored how individuals and communities adapt to the challenges of climate change through mobility.

This is based on the hypothesis that the transformation of vegetation, agricultural territories, and aquatic ecosystems into urban environments and wastelands compelled younger farmers to relocate to metropolitan regions, resulting in the abandonment of farmlands. This situation adversely affects food security and intensifies the challenges associated with food insecurity. Their empirical analysis of how people in Lagos, Nigeria, adapt to climate change through mobility involved a mixed-methods approach, using surveys and semi-structured interviews. The findings from this study indicate that flooding significantly influenced migration intentions, whereas many residents were constrained from moving due to economic, social, and political factors. While some residents considered government-supported relocation initiatives, others remained uncertain due to a lack of trust. Consequently, some individuals express a preference for community-based relocation options.

With the use of a mixed-method approach, utilising questionnaires, focus group discussions, and interviews, Halliru *et al*. (2024) empirically studied how small-scale farmers in Nigeria's north perceive the impacts of climate change as determining the rate of human migration. Results indicated that farmers perceive climate variability as a significant risk. They implemented environmental management practices and diversified their livelihoods to mitigate vulnerability.

The review of relevant studies identified several gaps in the existing literature. First, data that can be used to provide a complete overview of Nigeria's environmental and climatic conditions are limited. Additionally, several studies focused on short periods, which may not represent the dynamic of migration as a response to environmental/climate changes in Nigeria. A huge gap persists in quantifying the recent trends of environmental and climatic drivers of migration in Africa's most populous country – Nigeria. Furthermore, few studies have provided limited empirical results to identify the position of the roles played by the environment and climate in influencing migration decisions among other factors. In addition, scant empirical studies have been conducted to ascertain the impacts of in-migration on the land-use dynamics of the destination regions. This gap is critical, as it will be necessary to develop effective policies and strategies to address the challenges of environment and climate-induced migration.

The current study seeks to address these gaps by providing a long-term analysis of environmental and climate-induced migration in Nigeria using qualitative and quantitative (mixed-method) approaches. This will contribute to the body of knowledge on environment and climate-induced migration and provide insights into policies and strategies that can inform efficient migration management in Nigeria and beyond. This research is relevant, especially for implementing SDGs and proposing solutions to the challenges posed by environment and climate-induced migration. This will help develop adequate adaptation strategies, especially at the local level.

2.5 The Overview and Key Issues of the Study

2.5.1 Overview of climate and Environment-induced migration issues

The phenomenon of migration induced by environmental and climate forcing has been a global concern since the early 1990s. This issue requires further attention at the policy level and from key stakeholders because the current knowledge base is relatively fragmented and lacks sufficient local and community-based perspectives. The debate on climate change and migration in Nigeria has progressed from an initial focus on economic and agricultural changes to a more focused examination of environmental factors, including flooding, drought conditions, and land degradation.

Key themes include the environment and climate as migration drivers, with households using migration to manage agricultural risks and cope with erratic weather. In regions like northern Nigeria, migration has been a longstanding strategy for addressing agricultural failures, intensified by rising temperatures and land degradation (Ologeh *et al*., 2021). Urban areas like Lagos face migration pressure from flood risks, and economic and social factors often constrain residents' mobility (Ekoh *et al*., 2022). Migration also affects food security, as urbanisation and land use change leave agricultural lands uncultivated (Okeleye *et al*., 2023). Gender dynamics are critical because men and women experience migration differently due to socio-cultural roles (Akinbami, 2021).

Critical research issues include developing gender-sensitive policies, harnessing migration as a resilience strategy, addressing food security risks from land-use changes, and supporting populations unable to migrate. Effective adaptation strategies require addressing these multifaceted challenges through informed, targeted interventions.

2.5.2 Key issues of the study

Nigeria has environmental laws, including the NESREA Act of 2007 and the Climate Change Act of 2021 (Babaniyi *et al*., 2024). However, these legislative tools do not explicitly address the migration linked to climate change. The National Adaptation Strategy and Plan of Action (NASPA-CCN) identified migration as a coping mechanism lacking robust enforcement. Despite the laudable objective of these bodies to address climate risks, they lack specific migration-focused policies, which leaves gaps in managing climate-induced displacement. A further challenge is the lack of coordination between key agencies, such as NESREA (National Environmental Standards and Regulations Enforcement Agency), National Emergency Management Agency (NEMA), and the Ministry of Environment. Underfunding, limited technical capacity and insufficient logistical support hinder these institutions' ability to manage climate-induced migration (Olujobi, 2024).

Migration management remains reactive, with insufficient integration between climate change mitigation and migration governance. Reliance on international funding without sustainable local resources may further complicate long-term adaptation strategies. Programmes such as the Great Green Wall and Nigeria's Nationally Determined Contributions (NDCs) can address climate change but lack explicit migration components (Nzegbule and Obiajunwa, 2024). Significant challenges include policy fragmentation, inadequate funding, and insufficient attention to vulnerable populations, particularly women and rural communities. Furthermore, interventions are required to address gender sensitivity and the issue of involuntary immobility caused by the changing climate and environmental degradation.

CHAPTER THREE

3.0 MATERIALS AND METHODS

This chapter describes the materials and data used, methods of data collection, data analyses, and presentation. A summary is shown in Figure 3.1.

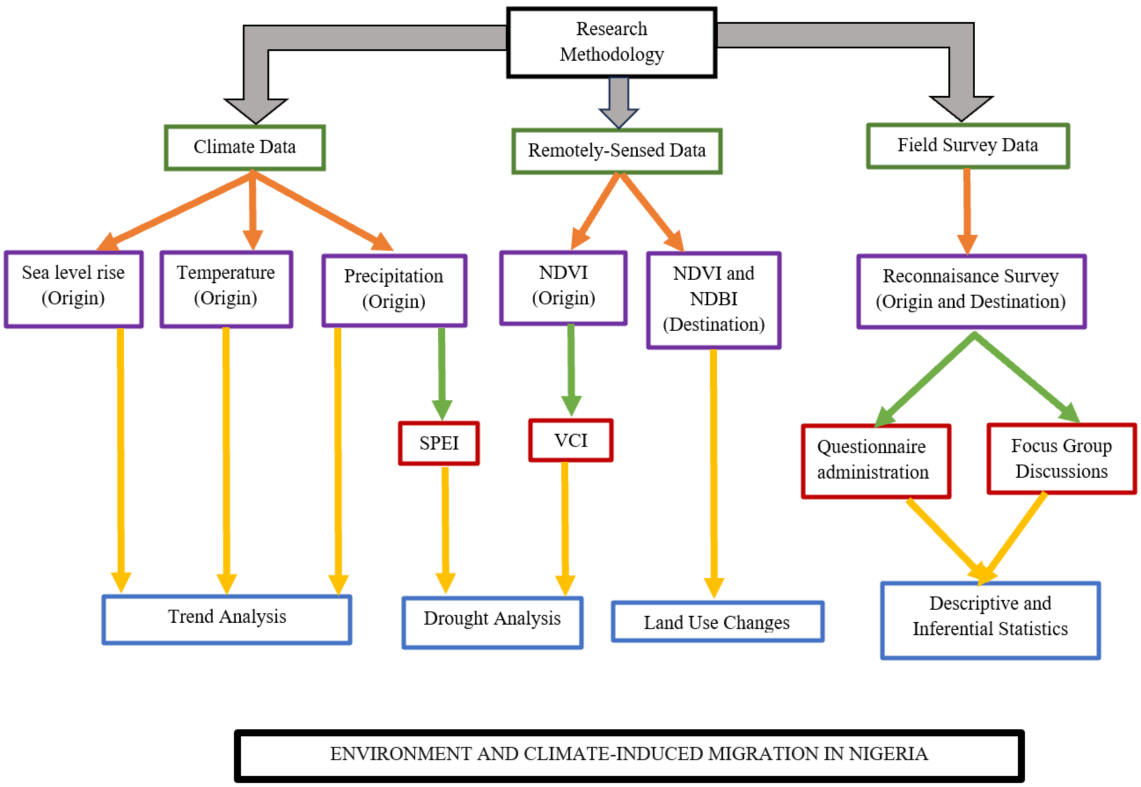


Figure 3.1: Flowchart of Methodology

Source: Author (2024))

3.1 Description of Materials

This study utilised a mixed-method approach, which is a combination of qualitative and quantitative data obtained from primary and secondary sources. The main instruments used for this research comprised Global Positioning System (GPS) tools, satellite images, Google

Earth Engine (an online-based platform for data extraction), and a KoboToolbox-enabled smartphone (for primary data collection). The summary is presented in Figure 3.1.

3.2. Methods of Data Collection

3.2.1 Climatic indicators at migration origins

To address the first research question, data from the 30 years (1993–2022) of annual temperature and precipitation was accessed using the Google Earth Engine (GEE). These variables are critical indicators of climate patterns in the study area. The GEE is a cloud-based platform that retrieves and analyses environmental datasets through its scripting interface. It can be used to facilitate the precise extraction of the necessary data for the selected location and time frame.

I. Temperature

Monthly temperature data was sourced from the Fifth Generation of ECMWF Reanalysis (ERA5) produced by the European Centre for Medium-Range Weather Forecasts (ECMWF) (Lavers *et al*., 2024). ERA5 has a spatial resolution of about 31 km (Table 3.1) and provides a consistent and reliable dataset by integrating various observation sources (Hersbach *et al*., 2020). It has a temporal resolution of hourly data. The annual temperature data from 1993 to 2022 was acquired using the Google Earth Engine (GEE) platform (https://earthengine.google.org). ERA5 has been demonstrated to outperform other reanalysis data in representing the mean and extreme climates over West Africa due to its enhanced representation of inter-annual variability and better capture of the annual cycle (Gbode *et al*., 2023). The enhanced representation of interannual variability and improved capture of the annual cycle resulted in a notable reduction in temperature bias, particularly in comparison to the previous generation of ERA-Interim. Furthermore, the data can be utilised for investigating heatwaves, cold spells and other extreme temperatures, as well as the effects of temperature on agriculture, health and infrastructure in West Africa (Domeisen *et al*., 2023; Ngoungue-Langue *et al*., 2023). This makes it a viable tool for climate trend analysis over extended periods (Liu *et al*., 2020).

II. Precipitation

The annual precipitation data was sourced from the Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS), developed by the Climate Hazards Group at the University of California, Santa Barbara. CHIRPS is a satellite-based precipitation dataset that combines infrared and microwave satellite data with ground-based observations to provide high-resolution precipitation estimates (Shen *et al*., 2020). The dataset was created by combining satellite images with on-site station information, offering a strong representation of precipitation patterns across a range of temporal and spatial scales (Zeng *et al*., 2023). CHIRPS has a resolution of approximately 5 km (Table 3.1) and was obtained for the periods between 1993 and 2022 using the Google Earth Engine (GEE) platform (https://earthengine.google.org). It has been validated and compared with other precipitation datasets, demonstrating its ability to estimate precipitation patterns and extremes accurately (Rivera *et al*., 2019; Gupta *et al*., 2020; López-Bermeo *et al*., 2022; Zeng *et al*., 2023).

By integrating satellite observations with ground-based measurements, CHIRPS ensures improved accuracy and reliability of precipitation estimates. CHIRPS places drier-than-normal seasons in a historical context, thereby becoming a viable tool for drought early warning systems, monitoring rainfall deficits, and assessing drought severity and impacts

(Sa'adi *et al*., 2023; Amosi and Anyah, 2024; Watmough *et al*., 2024). CHIRPS is generally preferred for studying rainfall due to its higher resolution, better representation of rainfall variability, and improved accuracy over complex terrains. Researchers have established that in Nigeria, CHIRPS precipitation data have a higher correlation and accuracy in estimating monthly rainfall than other products when evaluated with ground-based observations (Akinyemi *et al*., 2020; Ogbu *et al*., 2020; Salami *et al*., 2020; Datti *et al*., 2024; Dawa *et al*., 2024), suggesting CHIRPS as a reliable source of precipitation data in Nigeria.

III. Sea Level Rise

Data was sourced from the Copernicus Climate Change Service (C3S) to investigate sea level anomalies along the Nigerian coastline. This dataset provides gridded daily and monthly mean global sea level anomaly estimates based on satellite altimetry measurements (Legeais *et al*., 2021). Using updated altimeter standards, the sea level anomalies are computed relative to a 30-year mean reference period (1993-2022). The C3S dataset is climate-oriented, focused on monitoring the long-term evolution of sea level rise and generating ocean climate indicators (Simoncelli *et al*., 2022). A spatial resolution of approximately 28 Km (Table 3.1) and a two-satellite merged constellation ensure both the accuracy and stability of the sea level record (Melet *et al*., 2021), which is essential for capturing regional variations along the Nigerian coast. The sea level dataset has a more operational focus on retrieving mesoscale signals in the context of ocean modelling and ocean circulation analysis on a global or regional scale (Legeais *et al*., 2021). These variations can differ significantly from global averages, highlighting the need for precise regional assessments. Nevertheless, integrating sea level data with other climate indicators can support decision-making processes.

3.2.2 Ecological health indicators at migration origins

3.2.2.1 Normalized difference vegetation index

The Normalized Difference Vegetation Index (NDVI) is a dimensionless quantity first suggested in 1979 as an index commonly considered a reliable ecological indicator for monitoring vegetative health and assessment of drought conditions in a region, especially in Nigeria (Adedeji *et al*., 2020; Afuye *et al*., 2022), with values ranging from -1 to +1. High NDVI values correspond to areas with high vegetation coverage and vice versa. It is computed as the ratio of the difference between the reflected red light and the reflected near-infrared band to the sum of the two bands (Equation 3.1).

$$\mathrm{NDVI} = \frac{\mathrm{NIR} - \mathrm{red\ band}}{\mathrm{NIR} + \mathrm{red\ band}} \tag{3.1}$$

The annual NDVI data was obtained from the Moderate Resolution Imaging Spectroradiometer (MODIS), onboard the National Aeronautics and Space Administration (NASA)'s Terra and Aqua satellites. With a spatial resolution of 250 m, MODIS offers high-quality, global remotely sensed data, such as NDVI. MODIS NDVI is particularly suitable for vegetation and drought studies because the 16-day composite was designed to minimise the impact of cloud cover, ensuring more reliable data (Zeng *et al*., 2021), especially in Nigeria (Orimoloye *et al*., 2021). This is achieved by employing an atmospheric correction algorithm to transform top-of-the-atmosphere radiance data into corrected reflectance values for specific bands. Based on its availability, 20 years (2003–2022) of annual MODIS NDVI data was acquired on GEE to analyse and visualise the vegetation dynamics across different locations and time scales.

3.2.3 Land degradation at the location of the migration destinations

A portable Global Positioning System (GPS) was used to obtain all the coordinates of the 12 locations. To assess the land degradation status through the spatiotemporal changes of vegetation and build-up within the last decade at the study locations, 30 m spatial resolution collection 1 tier remotely sensed imagery scenes and data were obtained from Landsat 8 Operational Land Imager (OLI) between 2014 and 2023 using the GEE platform. Images were selected from December, which represents the peak of the dry season, to obtain the highest quality and consistent data with the least cloud cover within the context of the regular yearly pattern for locations in the tropical savannah (Idrees *et al*., 2022). The Fmask (Function of mask) algorithm was employed to select Landsat scenes from a single date, thereby ensuring minimal influence of cloud cover and shadows (Zhu *et al*., 2018). The mean of all values at each pixel across the stack of all matching bands for the two scenes available for the December image collection was then calculated. Afterwards, the Normalised Difference Vegetation Index (NDVI) and Normalised Difference Built-Up Index (NDBI) values were generated using the spectral bands of the Landsat 8 datasets (as replicated from section 3.2.2). This was done to characterise the changing land degradation status of the communities.

NDVI is a widely used indicator for monitoring vegetation health and detecting land degradation (Yengoh *et al*., 2015). It is based on the difference between the near-infrared (ranging between 0.85 µm - 0.88 µm for Landsat 8/9) and red reflectance (ranging between

0.64 μm - 0.67 μm) (Gutman *et al*., 2021). A decline in NDVI over time indicates a loss of vegetation cover, a key indicator of land degradation.

The normalised difference built-up index (NDBI) is a useful metric for assessing the intensity of urbanisation, land cover change and land degradation in an area (Kebede *et al*., 2022). It is based on the difference between the shortwave infrared (SWIR) (wavelength ranging between 1.57 μm -1.65 μm for Landsat8/9) and NIR reflectance (0.85 μm - 0.88 μm). The calculation of NDBI is expressed using Equation 3.10:

$$\mathrm{NDBI} = \frac{\mathrm{SWIR} - \mathrm{NIR}}{\mathrm{SWIR} + \mathrm{NIR}} \tag{3.10}$$

SWIR and NIR are the shortwave infrared and near-infrared spectral bands of the Landsat 8 data, respectively.

NDBI values range from -1 to +1, high NDBI values indicate large proportions of built-up areas and impervious surfaces (Zheng *et al*., 2021). An increase in NDBI values suggests the conversion of natural lands to urban or built-up areas, which is also a form of land degradation. The analysis of NDVI and NDBI changes complements each other to provide an in-depth understanding of land degradation trends by capturing vegetation loss and expanding built-up areas (Kumar *et al*., 2022).

Table 3.1: Summary of Data Types and Sources Used for the Study

Data Type	Data Source	Resolution	Period	Use	Locations (LGAs)
Precipitation	CHIRPS	5km	1993 - 2022	Climate Change Indicator	Kano Municipal, Kwali, Warri South West, Brass
Temperature	ERA5	31km	1993 - 2022	Climate Change Indicator	Kano Municipal, Kwali, Warri South West, Brass
SLR	C3S	28km	1993 - 2022	Climate Change Indicator	Warri South West, Brass
NDVI	MODIS	250m	1993 - 2022	Ecological health Indicator	Kano Municipal, Fagge, Gwagwalada, Kwali
SPI	CHIRPS	5km	1993 - 2022	Ecological health Indicator	Kano Municipal, Fagge, Gwagwalada, Kwali
VCI	MODIS	250m	1993 - 2022	Ecological health Indicator	Kano Municipal, Fagge, Gwagwalada, Kwali
NDVI and NDBI (Land Use Changes)	LANDSAT	30m	2014-2023	Land Use Changes	Kano Municipal, Fagge, Gwagwalada, Kwali
Field survey (household survey, FGD)			2023		Perceptions of the influence of the climate and environment on migration

3.2.4 Method of primary data collection

The primary data was obtained by administering questionnaires (Appendix A) to respondents from the selected locations and through focus group discussions (FGDs) (Appendix B). This was designed to acquire qualitative and quantitative data from respondents to identify key environmental and climate indicators that influence migration. Migration hotspots were selected based on the "intersection" of geopolitical and ecological zones. Major migration origin and destination communities with environmental impacts were identified through a literature review and expert knowledge (Clement, 2013; McIntyre, 2014; Kperegbeyi and Ogboi, 2015; Mokwenye, 2020; Michael, 2024). For example, the communities of Sabon Gari East and Sabon Gari West have long been known to be some of the oldest immigrant settlements in Kano, dating back to the trans-Saharan trade in the 14th and 15th centuries, and have been persistent destination hotspots for migrants to date (Muhammad and Abdulraman, 2022). In the indigenous language (Hausa), Sabon Gari is interpreted as "strangers' quarters", meaning an area earmarked for the settlement of migrants in the community (Muhammad and Abdulraman, 2022). Zuba and Tungamaje experienced in-migration due to economic and job opportunities, urban infrastructure, and proximity to the Federal Capital City of Abuja (Adikwu *et al*., 2021), while the coastal communities are known for out-migration (Michael, 2024).

The survey targeted the origin and destination migrant households in the selected study locations (Table 3.2). A community entry was carried out in each community to provide an overview of the study and obtain the consent of the local authorities to conduct data collection. An initial draft of the instrument was designed and pretested as a reconnaissance survey using a purposive sampling technique to refine the survey instrument for a study on climate and environment-induced migration across the study locations. The pretest evaluated the clarity, relevance, and respondents' understanding of the survey questions. Approximately 10 respondents were selected per community, representing 10 to 15 percent of the main study's sample size (Buschle *et al*., 2022; Pan and Carpenter, 2023). Face-to-face interviews were conducted, and feedback was gathered to identify areas for improvement. Based on the results, the questionnaire was refined to ensure clarity and suitability for the larger study.

Table 3.2: Nature of the Study Locations

State	LGA	Community	Migration Direction
Delta	Warri South West	Ugborodo	Origin
		Ogidigben	Origin
Bayelsa	Brass	Twon	Origin
		Odioma	Origin
Abuja	Gwagwalada	Zuba	Destination
		Tungamaje	Destination
	Kwali	Central	Origin and Destination
		Wako	Origin and Destination
Kano	Kano Municipal	Zango	Origin and Destination
		Tundun Nufawa	Origin and Destination
	Fagge	Sabon Gari East	Destination
		Sabon Gari West	Destination

3.2.4.1 Sample size and selection of respondents

A multi-stage cluster sampling design was adopted to capture a good coverage and representation of the target population and reduce sampling errors. 12 communities were identified and selected in the first stage based on official enumeration areas (EA) from six LGAs nationwide (Figure 3.2). Secondly, expert knowledge was used to determine the migrants' origin and destination enclaves in each community (See Table 3.2). The survey was conducted in EAs as cluster communities, as adopted by Oyeniyi (2013) and also recommended by Taiwo *et al*. (2023) for enhanced information accuracy. Finally, ninety household heads were purposively selected for each EA (totalling 1080 respondents in 12 EAs nationwide). The household heads were identified and selected due to their easy accessibility and willingness to participate in the survey at a higher response rate (as utilised by Okeleye *et al*. (2023) and Aweda *et al*. (2024). This approach was used to capture a wide range of the different perceptions and experiences of the respondents (Palinkas *et al*., 2015) and provide a more accurate representation of the broader community's experiences with climate and environment-induced migration (Etikan *et al*., 2016).

Semi-structured and structured questionnaires were administered to both internal migrants and non-migrants in equal proportions. Internal migrants are individuals or households who relocate within the country, while non-migrants remain in their original residence. The questionnaires were in English, and a Field Assistant in each study location was employed as a translator into the native dialect understood and spoken by the respondents. The data collection process was conducted by digitally integrating the questionnaire survey into the KoboToolbox mobile application (Version 2.022.44) on mobile devices to ensure the accuracy and integrity of the collected data. These activities took place between March 2023 and August 2023.

A joint interaction session was carried out in each community as FGDs. Guidelines for open-ended questions were given to provide a broad framework within which the FGDs. There were 12 FGD sessions, one from each community. 10 to 15 FGD participants comprising migrants, non-migrants, community leaders and various household heads in each community were purposively selected as participants of the FGDs. The FGD size allows for active participation to enhance insightful interactions among the participants, with everyone having the opportunity to contribute to the discussion (Sim and Waterfield, 2019). The participants' ages ranged from 25 to 60. The FGDs took place in open spaces suitable for participation and lasted about one hour in each community. Efforts were made to ensure the respondents' cooperation in the interviews and FGDs by clearly explaining the purpose and aim of the study.

The discussion focused on issues regarding the environment and climate of the local communities, how it influences the migration of people and households out of that community (of origin), and how migration has influenced the environment of destination communities. The audio records taken from the FGDs were translated and transcribed from the native languages and Pidgin English (the vernacular version of English) into English.

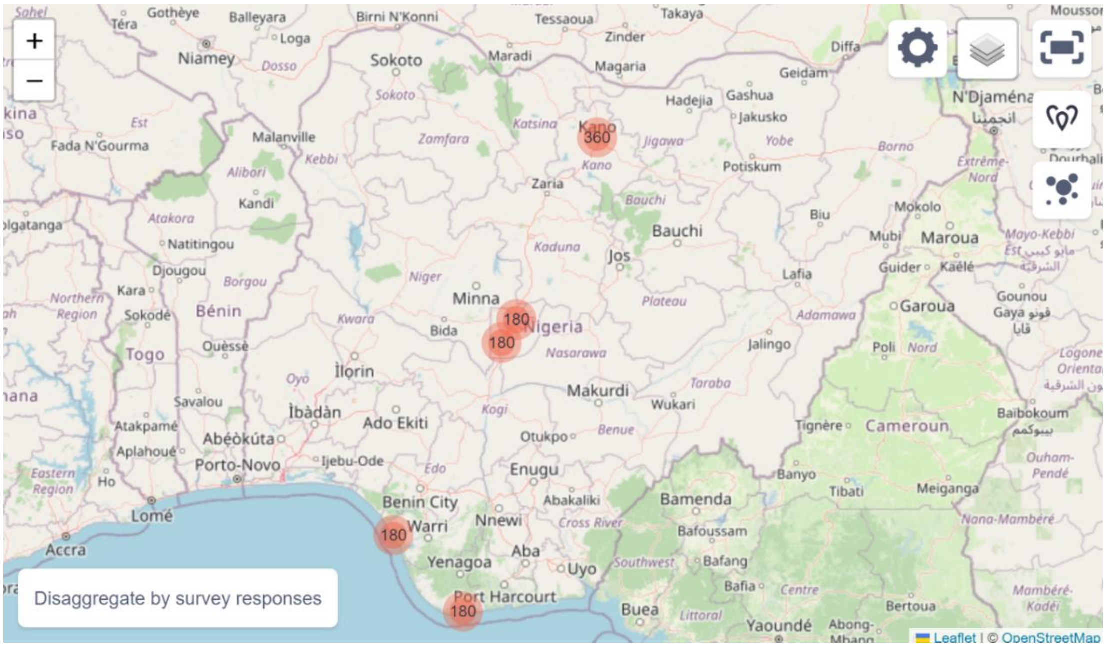


Figure 3.2: Number of Respondents at the LGAs of the Study Locations

Source: Author (2024)

3.2.4.2 Ethical considerations

Ethical issues were addressed, and considerations were strictly adhered to. A letter of introduction and permission to execute the field survey was obtained from the Doctorate Research Programme, West African Science Center for Climate Change and Adapted Land Use, Climate Change and Human Habitat (WASCAL CCHH), which was presented at each study location. Given the potentially sensitive nature of migration issues, the participants were approached with empathy and respect. With the assurance of anonymity and confidentiality in their responses, the respondents gave their consent before the interviews and discussions, and they were informed that this study would not negatively impact the community or any individual. Participation was voluntary, and participants were informed of the study's purpose, procedures, and benefits. No participant was influenced to participate in the study.

Participants were informed of their rights to ask questions and were free to decline participation or withdraw at any time without any negative consequence. They were informed about how their data would be used. To ensure anonymity, reports, presentations or publications will be aggregated such that no individual or household can be identified. The data collected will be securely stored in encrypted databases or password-protected electronic systems, with access limited to authorised research personnel.

3.3 Method of Data Analysis

3.3.1 Examining the trends of ecological indicators and climatic variables

The trends of the ecological and climatic indicators were analysed using the Mann-Kendall (MK) test. The Mann-Kendall (MK) test (Mann, 1945; Kendall, 1946). It is a nonparametric statistical method commonly used to identify and assess the significance of monotonic trends in climatological and environmental data time series, vegetation cover, and time series, and study vegetation dynamics response to climate change (Ogunrinde *et al*., 2021; Sonali and Paul, 2021). The test assumes that observations should be independent and identically distributed if no trend is observed in the data. It has the advantage of being less sensitive to outliers than the parametric method (Sam *et al*., 2022).

The Mann-Kendall test starts by calculating the S statistics as computed below:

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} \mathrm{sign}(Tj - Ti) \qquad (3.2)$$

$$\text{sign}(Tj - Ti) = \begin{cases} 1 \text{ if } Tj - Ti > 0 \\ 0 \text{ if} Tj - Ti = 0 \\ -1 \text{ if } Tj - Ti < 0 \end{cases} \tag{3.3}$$

Where Tj and Ti are the data values at times j and i, where j is greater than i, and n indicates the length of the dataset. While a positive value of S indicates an increasing trend, a negative of S indicates a decreasing trend. A positive (negative) value of S indicates an upward (downward) trend. For $n \geq 10$, the statistic *S* is approximately normally distributed with the mean and variance (σ^2) for the S-statistic is defined by:

$$\sigma^2 = \frac{n(n-1)(2n+5) - \sum t_i(i)(i-1)(2i+5)}{18} \tag{3.4}$$

The summation term in the numerator is used only if the data series contains tied values. The standard test statistic Zs is calculated as follows:

$$Z_s = \begin{cases} \frac{s-1}{\sigma} \text{ for} S > 0 \\ 0 \text{ for } S = 0 \\ \frac{s+1}{\sigma} \text{for} S < 0 \end{cases} \tag{3.5}$$

The test statistic Zs is used as a measure of the significance of the trend.

The magnitude of the time series trend will be computed using a non-parametric method described using this equation:

$$\beta = \frac{x_j - x_k}{j - k}, j > k \tag{3.6}$$

Where β is the Sen's slope estimate, $\beta > 0$ indicates an increasing trend in the time series and $\beta < 0$ means a decreasing trend.

To identify trends in a time series, it is important to ascertain the independence of subsequent data in the series based on statistical tests, as trend tests can be affected by serial correlation in the data. A positive serial correlation can lead to the wrongful rejection of the null hypothesis of no trend, resulting in a type I error, just as a negative serial correlation can lead to the acceptance of the null hypothesis of no trend, leading to a type II error. The lag−1 serial correlation coefficients were calculated to detect serial correlation as proposed by Kendall *et al*. (1946) in Equations 3.7 and 3.8:

For any time series Xi= x_1, x_2, ….., xn, lag−1 serial correlation coefficient (P_1) is calculated as

$$P_1 = \frac{\frac{1}{n-1}\sum_{i=1}^{n-1}(x_i - E(x_i))(x_{i+1} - E(x_i))}{\frac{1}{n}\sum_{i=1}^{n}(x_i - E(x_i))^2} \quad (3.7)$$

$$E(x_i) = \frac{1}{n}\sum_{i=1}^{n} n \quad (3.8)$$

Where $E(x_i)$ is the mean of the sample and n is the sample size

The probability limits for P_1 on the correlogram of an independent series are given as Equation 3.9.

$$P_1 = \begin{cases} \frac{-1+1.645\sqrt{n-2}}{n-1} \text{ (for the one} - \text{tailed test)} \\ \frac{-1\pm 1.96\sqrt{n-2}}{n-1} \text{ (for the two} - \text{tailed test)} \end{cases} \quad (3.9)$$

The modified Mann-Kendall test is an extension of the original Mann-Kendall test and was devised to address the effects of serial correlation in the data, particularly in instances where the data exhibits strong autocorrelation (Hirsch and Slack, 1984; Mallick *et al*., 2021). This is because such effects can significantly affect the accuracy of the test results. The modified

Mann-Kendall test has been used to detect trends in climate data, including temperature and precipitation patterns, and to analyse trends in agrometeorological data (Qureshi *et al.*, 2023). Therefore, the modified Mann-Kendall test was used, having detected significant serial correlation in the time series.

3.3.1.1 Standardised precipitation evapotranspiration index

The Standardised Precipitation Evapotranspiration Index (SPEI) is a widely known and valuable tool for quantifying and monitoring drought conditions by providing insights into precipitation deficits over different timescales, as proposed by Vicente-Serrano and Beguería (2016). The SPEI makes up for the limitations of the Standardised Precipitation Index (SPI) by capturing how water demand is impacted by increased temperatures, making it viable for adequate drought assessment and monitoring in temperature-sensitive regions and its impact on agriculture, water resources and ecosystems. This is achieved by combining precipitation and potential evapotranspiration (PET) estimated from temperature data using methods like the Thornthwaite equation proposed by Thornthwaite (1948). The SPEI is calculated as the difference between the precipitation (P) and PET for the month, i (Equation 3.11).

$$\mathrm{SPEI_i} = \mathrm{P_i} - \mathrm{PET_i} \qquad (3.11)$$

where the PET is calculated using the Thornthwaite equation (Equation 3.12):

$$\mathrm{PET} = 1.6\mathrm{K}\left(\frac{10\mathrm{T}}{\mathrm{I}}\right)^{\mathrm{m}} \qquad (3.12)$$

Where T is the mean temperature, I is the annual heat index, m is a coefficient depending on the heat index, and K is a factor of correction calculated as a function of the month and latitude.

For this study, the SPEI values were computed for the 12-month timescale to assess long-term drought patterns at each migration origin hotspot. The SPEI threshold ranges were used to define drought conditions, as shown in Table 3.3.

Table 3.3: Classification of SPEI

Classification	SPEI
Extremely wet	≥ 2.00
Moderately wet	1.50 to 1.99
Slightly wet	1.00 to 1.49
Near Normal	0.99 to -0.99
Mild drought	- 1.0 to -1.5
Moderate drought	-1.5 to -2.0
Extreme drought	≤ -2.00

Source: (McKee *et al.*, 1993)

3.3.1.2 Vegetation condition index

The Vegetation Condition Index (VCI) represents one of the most widely used remote sensing-based tools to monitor vegetation health and productivity (Moussa-Kourouma *et al.*, 2021). The VCI is a valuable tool for assessing ecological health, concisely measuring vegetation conditions and identifying trends and patterns in vegetation dynamics. Furthermore, it is effective in identifying areas experiencing drought stress (Salakpi, 2022). The Vegetation Condition Index (VCI) is calculated from the Normalized Difference

Vegetation Index (NDVI) as the difference between the current vegetation condition and the long-term minimum and maximum NDVI values for a given location. This makes it an appropriate tool for analysing the impact of drought, The VCI is computed as shown in Equation 3.13.

$$\mathrm{VCI} = \left(\frac{\mathrm{NDVI} - \mathrm{NDVI}_{\mathrm{min}}}{\mathrm{NDVI}_{\mathrm{max}} - \mathrm{NDVI}_{\mathrm{min}}}\right) * 100 \qquad (3.13)$$

Where NDVI is the current NDVI value, $NDVI_{min}$ is the historical minimum NDVI value, and $NDVI_{max}$ is the historical maximum NDVI value.

While NDVI measures vegetative health and density to indicate vegetation vigour and biomass, the NDVI-derived VCI provides better insights into its variations, making it more suitable for drought indications. Combining NDVI and VCI for this study improves the accuracy and reliability of drought assessment at the various migration origin hotspots. According to Kogan (1997), the VCI values range from 0 to 100, with different drought severity thresholds, ranging from no drought to extreme drought (Table 3.4).

Table 3.4: Drought Classification using VCI

Classification	VCI
No drought	≥ 50
Moderate drought	$35 \leq VCI < 50$
Severe drought	$20 \leq VCI < 35$
Extreme drought	< 20

Source: (Kogan, 1997)

3.3.2 Analysis of field survey data

The quantitative data from the survey was analysed using IBM-SPSS 27 and R (version 4.3.1). The data was imported into a Microsoft Excel Worksheet for preliminary data cleaning before analysis on SPSS. Descriptive and inferential statistics were used to quantitatively describe and summarise the respondents' perspectives on migration patterns and how the climate and environment influence them. The chosen level of significance was $\alpha = 0.05$. The one-way analysis of variance (ANOVA) was employed to test the varying perceptions among the respondents. The data on perceptions violated the assumptions of the ANOVA, which requires normality and homogeneity of variance. Consequently, a non-parametric alternative, the Kruskal-Wallis rank sum test (Ostertagova *et al*., 2014) was employed to ascertain the differences in perceptions among the communities. Once the significant differences between communities had been identified, pairwise comparisons were conducted to determine how specific communities differed in their perceptions. These included adjustments, such as the Bonferroni correction, to control the overall Type I error rate (false positive) in the case of multiple comparisons (Hollander *et al*., 2013).

Based on the acquired field survey data, Quantum GIS (QGIS) was the primary tool for analysis and mapping to provide a geospatial approach to creating internal migration flow maps at origin and destination hotspots in Nigeria. The migration flow maps visually represent the movement of people between various locations. The FlowMapper plugin in QGIS created visual flow lines representing migration between origin and destination regions. These flow lines were scaled based on the magnitude of migration (thicker lines for higher migration flows, and thinner lines for lower flows).

3.3.3 Analysing migration-induced land degradation at the destination communities

This study employs a novel methodological approach, integrating remote sensing data (NDVI and NDBI) with local community perceptions. This combination allows for a more detailed analysis of land degradation processes driven by migration, particularly at the community level. We evaluated the relationship between the remotely sensed processes and activities leading to land degradation as perceived by the respondents using the multinomial logistic regression model proposed by (Hedeker, 2003) to analyse clustered or longitudinal nominal or ordinal response data. This methodology has been previously used to examine the relationship between land use changes (dependent) and socioeconomic (independent) variables (Bekere *et al*., 2023), as well as community perceptions of population growth, economic activities, and climate (as independent variables) (Obateru *et al*., 2024). The factors (independent variables) leading to land degradation were identified based on local knowledge from field surveys at the study locations. The logistic regression model is often employed to assess the probability of the effects of independent variables on dependent variables (Bekere *et al*., 2023) (Equation (3.14)).

$$Logit(Y) = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \cdots + \beta_n X_n \tag{3.14}$$

where Y is the dependent variable, α is the intercept, $\beta_1 \ldots \beta_n$ are the coefficients of the associated independent variables, and $X_1 \ldots X_n$ are the independent variables. In this study, the NDVI and NDBI values as indicators of land degradation are the dependent variables, and the perceptions of activities leading to land degradation are the independent variables. This implies that changes in vegetation and built-up areas occurred due to identified activities that led to land degradation in each community.

The Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) were employed to determine the optimal model for regression analysis. In addition, the strength of the relationship between the observed land degradation processes and the perceived activities leading to land degradation was evaluated utilising the Nagelkerke R^2, as proposed in (Nagelkerke, 1991). Nagelkerke R^2 represents an adjusted R^2 value that quantifies the proportion of the overall variance in the dependent variable that can be explained by the independent variables included in the logistic regression model (Pate *et al*., 2023). The significance of these tests was established at a confidence level of 95 percent.

3.4 Method of Data Presentation

The results of the analyses were presented in the form of maps, tables, graphs and narrations for easy readability and understanding. The quantitative data analysis from temperature, precipitation, NDVI, standardised NDVI anomalies, SPI and VCI were presented as time series plots. The geospatial analyses were presented using maps of visualisation while the qualitative data analysis from the surveys was presented using tables and graphs. The FGDs were put into themes and presented using narrations.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Presentation and Analysis of Results

4.1.1 Examining the trends of climate indicators in the areas of origin

4.1.1.1 Analysis of temperature and precipitation patterns in Kano Municipal

The average annual temperature of Kano Municipal between 1993 and 2022 was 26.41°C (Table 4.5). There was a significant increase in temperature ($p < 0.05$), with an annual increase of 0.024°C (Table 4.1, Figure 4.1). This trend was accompanied by a Sen slope value of 0.023 (Table 4.1), indicating a positive trend. The minimum and maximum recorded temperatures were 26.64°C and 27.10°C, respectively, with a wide range of 1.46°C. The standard deviation was 0.39°C, indicating a relatively low variability. Furthermore, it exhibited an upward trend in precipitation (Sen's slope = 1.502) (Table 4.1), with an increase of 1.33 mm per year. The observed increase in precipitation was not statistically significant ($p = 0.378$), which was above the 5 percent significance level (Table 4.1). The annual precipitation in Kano Municipal, averaging 863.10 mm, exhibited a relatively high variation, with a standard deviation of 102.75 mm (Table 4.7). The minimum recorded annual precipitation was 702.58 mm, while the maximum was 1092.27 mm, resulting in a range of 389.69 mm. The skewness of 0.32 reveals a slight positive skew, indicating more years with below-average rainfall (Table 4.7).

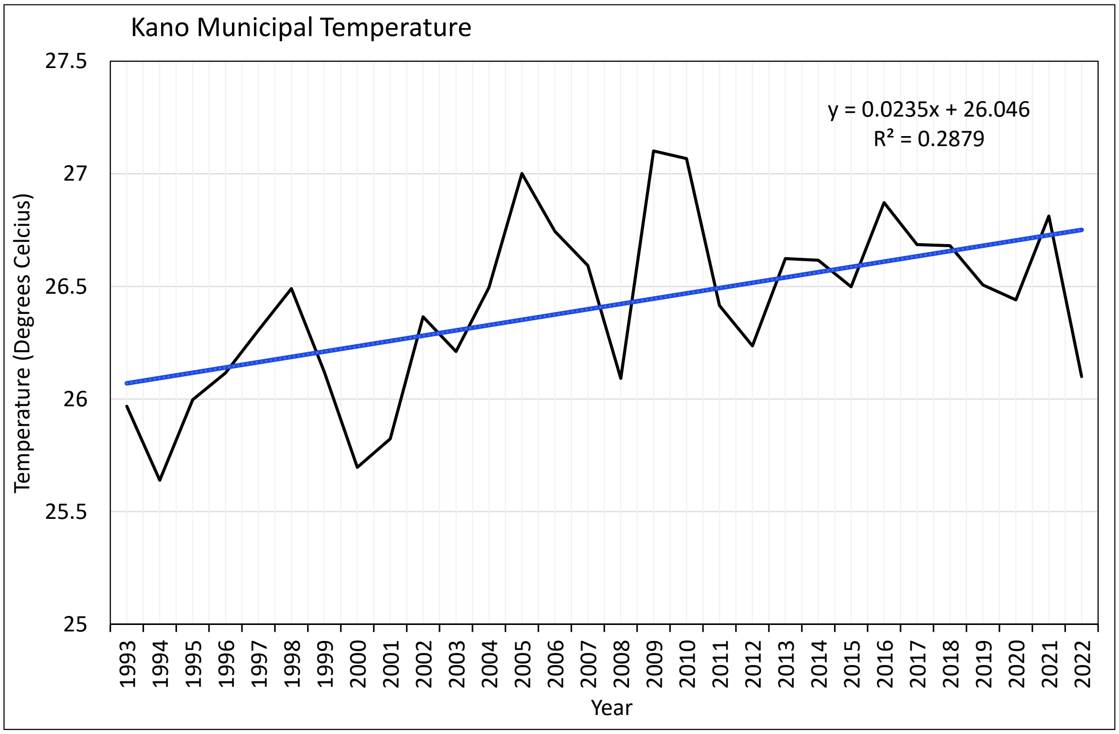


Figure 4.1: Annual Temperature at Kano Municipal for the Period 1993 - 2022

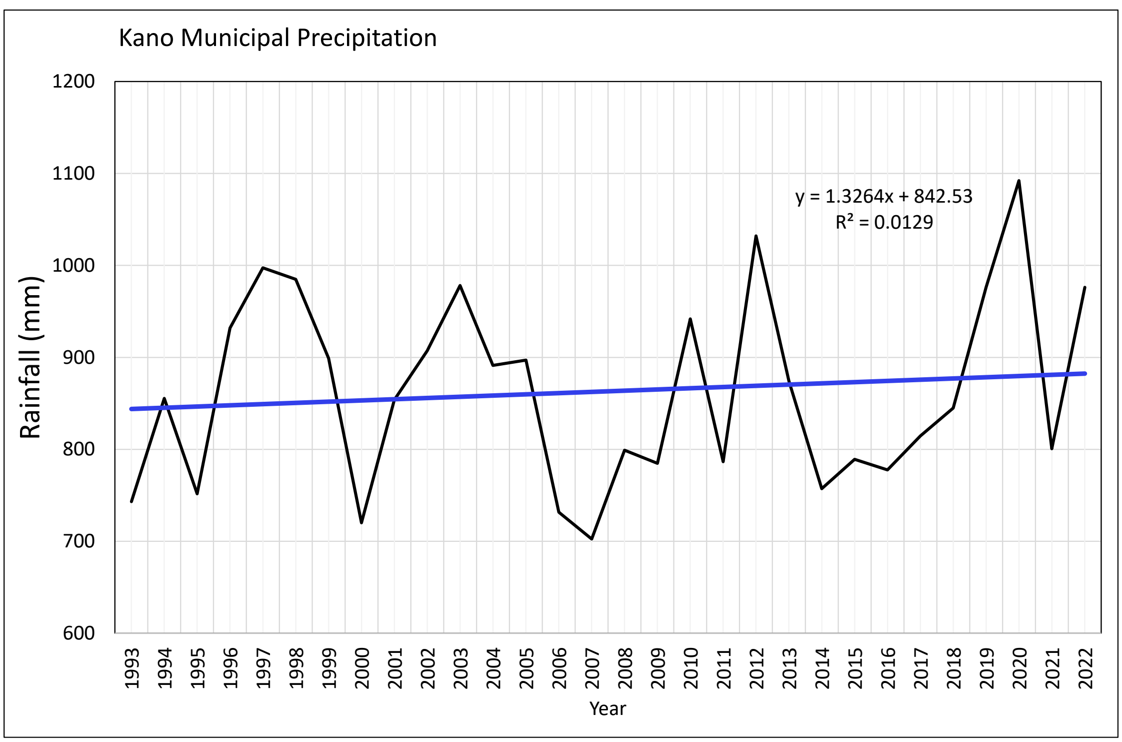


Figure 4.2: Annual Precipitation at Kano Municipal for the Period 1993 - 2022

Table 4.1: Trends of Temperature and Precipitation at Kano Municipal

Test	Temperature	Precipitation
P-value (two-tailed)	**<0.001***	0.378
Mann-Kendall stat (S)	5.013	0.881
Kendall's tau	0.398	0.053
Sen's slope	0.023	1.502
Trend	Significant increase	Not significant

Significant at p<0.05

The impact of the significant increase in temperature in Kano Municipal was expressed at its FGD. For example, a male FGD participant at Zango reported:

"A lot of things are changing around us due to the poor management of our surroundings and where we live. There is an increase in the prevalence of malaria due to an increase in mosquito population, which is brought about due to the heat (increase in temperature) that favours their breeding".

Another male FGD participant at Tudun Nufawa had a similar opinion regarding this:

"There is nothing much that we can do (regarding the increasing temperature), but we do our best to maintain it by ourselves by using local fans as a cooling system. As a community, we ensure that the remaining trees here are protected".

Despite the statistically non-significant increase in rainfall, an FGD participant at Zango highlighted the huge challenges posed by floods, often caused by poor urban planning and drainage systems.

"The flood situation is so much here that it sweeps our houses away. The floods take place due to the poor drainage systems here. The existing drainages are connected to the houses and when the drainages are blocked, the water will flow into the houses".

4.1.1.2 Trend analysis of temperature and rainfall patterns in Kwali

The average annual temperature of Kwali between 1993 and 2022 was 28.50°C (Table 4.7). A statistically significant increase in temperature was observed ($p < 0.05$), with a mean annual increase of 0.029°C (Table 4.2, Figure 4.3), a rate of change that was greater than that observed in Kano Municipal (Section 4.1.1.1). This trend was accompanied by a Sen slope of 0.029 (Table 4.2), denoting a positive trend. The minimum and maximum recorded temperatures were 27.81 °C and 29.33°C, respectively, indicating a considerable range of 1.52°C. The standard deviation was 0.36° C, indicating relatively low variability. By contrast, the precipitation data for Kwali exhibited a downward trend, as implied by a negative slope of -1.409 (Table 4.2, Figure 4.4) and a decrease of 2.21 mm per year. Despite the observed decline in precipitation, the statistical analysis did not identify any significant change ($p = 0.293$), which was above the 5 percent threshold for significance (Table 4.2). The mean annual precipitation in Kwali, at approximately 1,166 mm, exhibits considerable variability, with a standard deviation of approximately 121 mm (Table 4.7). The minimum recorded annual precipitation was 724.59 mm, while the maximum was 1372.22 mm, resulting in a range of 647.63 mm. The analysis of precipitation data in Kwali revealed high variability, with occasional years exhibiting significantly lower rainfall and negative skewness (-1.22). The high kurtosis value (3.74) indicates the presence of extreme precipitation events that may contribute to flood risks (Table 4.7).

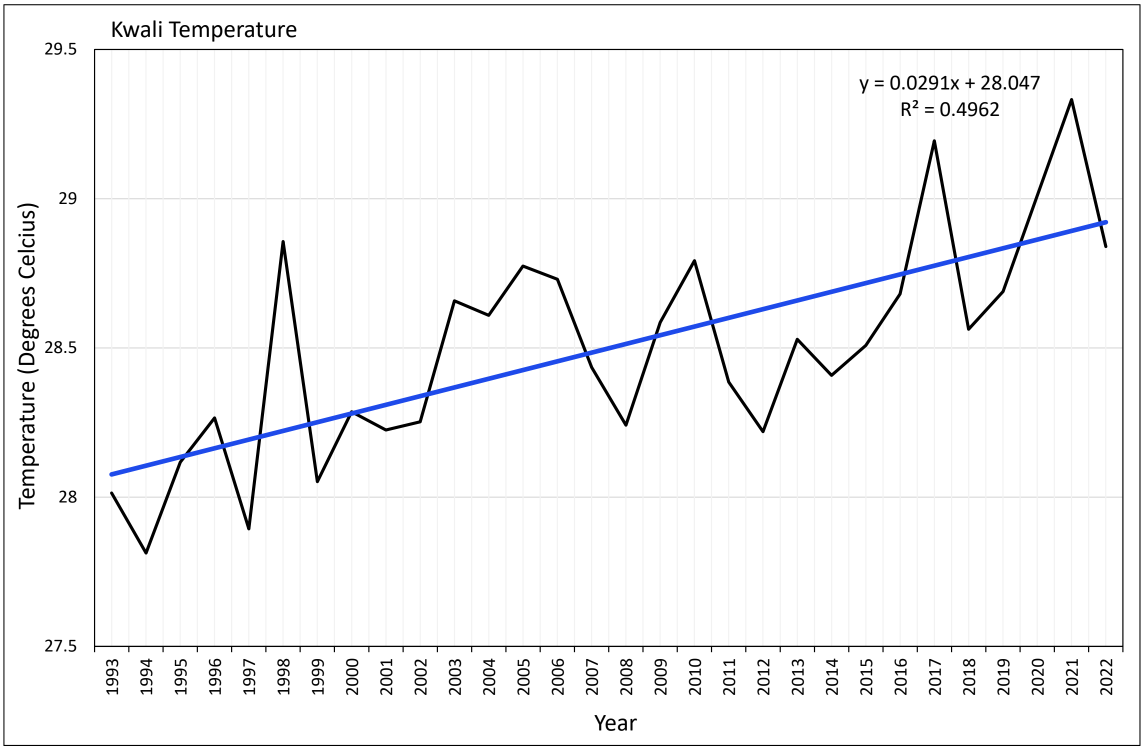


Figure 4.3: Annual Temperature at Kwali for the Period 1993 - 2022

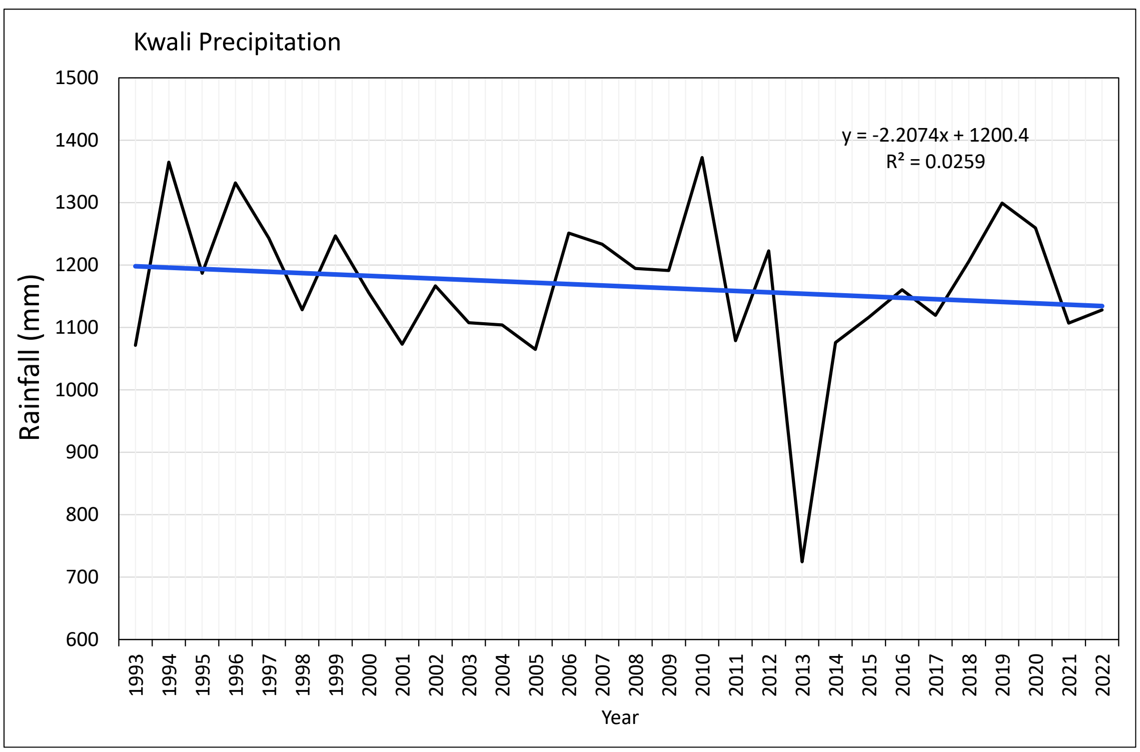


Figure 4.4: Annual Precipitation at Kwali for the Period 1993 - 2022

Table 4.2: Trends of Temperature and Precipitation at Kwali

Test	Temperature	Rainfall
P-value (two-tailed)	**<0.001***	0.293
Mann-Kendall stat (S)	9.109	2.069
Kendall's tau	0.499	-0.058
Sen's slope	0.029	-1.409
Trend	Significant increase	Not significant

Significant at p<0.05

The observed significant increase in temperature and a non-significant decrease in rainfall at Kwali LGA was echoed by FGD participants at Wako and Central. At Wako, a participant had this to say:

We experience so much heat. The lack of electricity affects us a lot because there is no other means of cooling. The persistence of heat also affects our health and leads to outbreaks such as malaria and measles. There is a shortage of rain right here

The changing pattern of rainfall was also a concern, as explained by another FGD participant who was a farmer:

The weather has changed drastically. There is an increase in the severity of drought right now. At this time of the year (July), we ought to have been harvesting maize, but that is not the situation right now.

On the other hand, an FGD participant at Central had a different opinion:

"The community has been in a nice area. Floods have not been experienced here before. It is true that the temperature has increased but we always find a way to cope with it".

4.1.1.3 Trend analysis of temperature and rainfall patterns in Warri South-West

The average annual temperature in Warri South West between 1993 and 2022 was 26.42°C (Table 4.7). A statistically significant increase in temperature was observed ($p < 0.05$), with a mean annual increase of 0.013°C (Table 4.3, Figure 4.7). This trend was accompanied by a Sen slope of 0.015 (Table 4.3), indicating an upward trend. The minimum temperature was 26.16°C, while the maximum temperature was recorded as 26.84°C, resulting in a narrow range of 0.68°C. The standard deviation is 0.21°C, revealing a low variability in temperature. A skewness of 0.71 indicates a slight positive skew, indicating higher temperatures. The temperature data exhibit minimal variability, which is typical for tropical regions.

Conversely, there was a significant downward trend in precipitation ($p < 0.05$), with an annual decrease of 17.01 mm (Table 4.3, Figure 4.8). The average annual precipitation was 3367.98 mm, indicating the region's high rainfall. There was a significant variability in the annual rainfall with a standard deviation of 456.06 mm. The minimum recorded annual precipitation was 2463.66 mm, while the maximum was 4278.96 mm, providing a range of 1815.30 mm (Table 4.7).

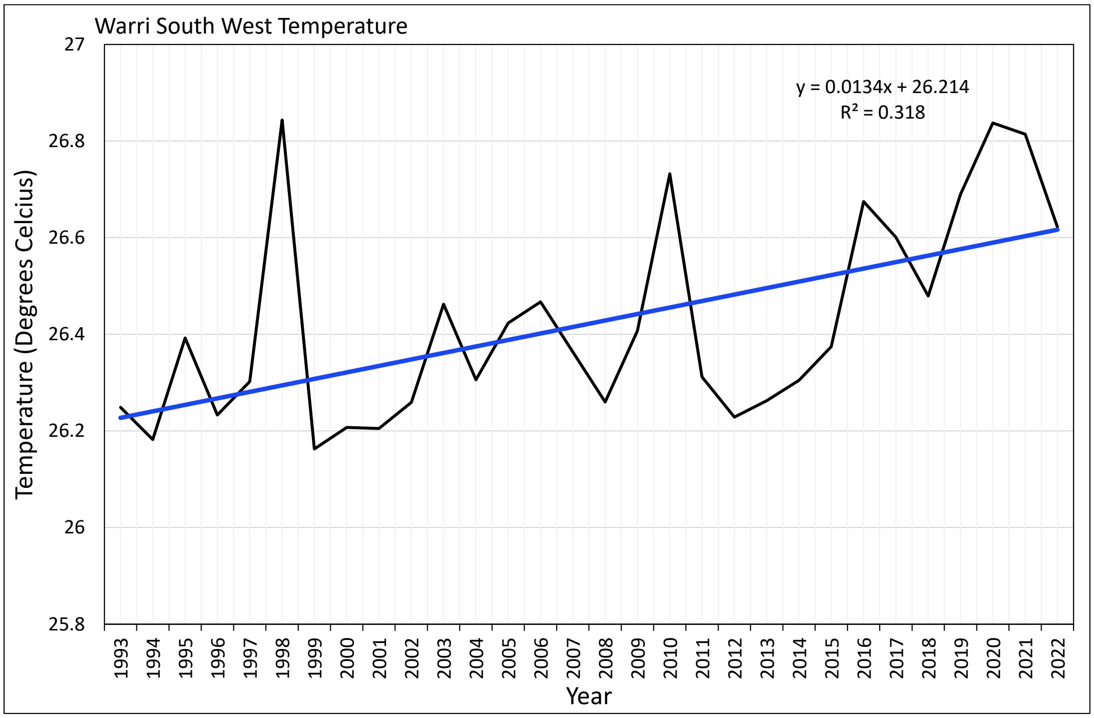


Figure 4.5: Annual Temperature at Warri South West for the Period 1993 - 2022

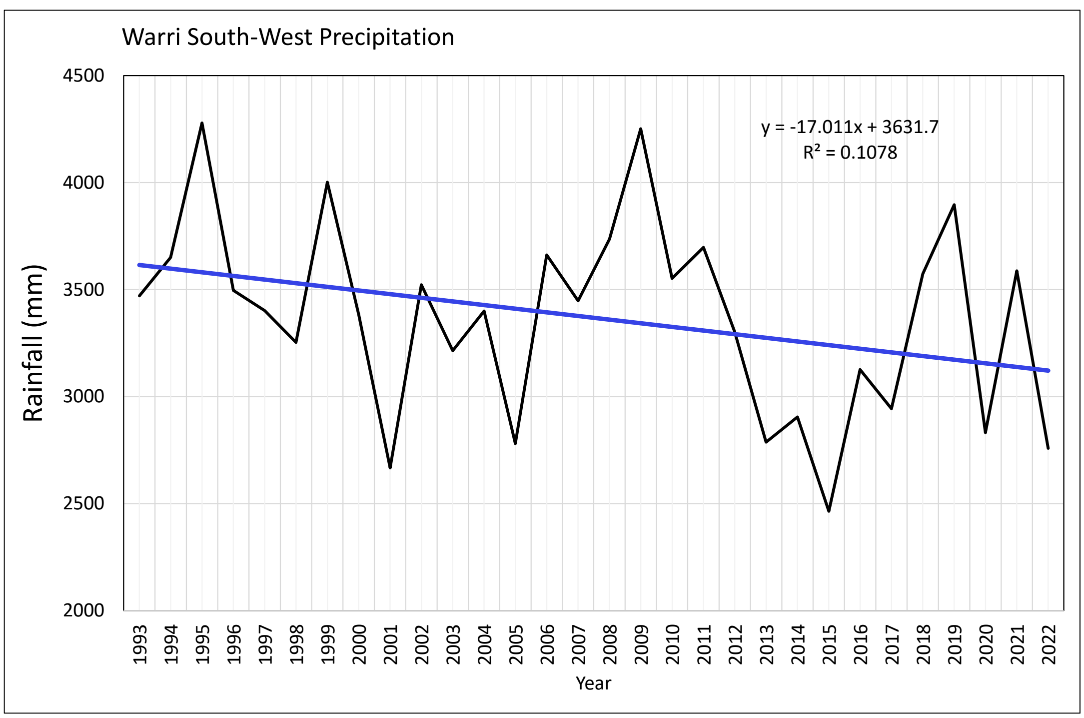


Figure 4.6: Annual Precipitation at Warri South-West for the Period 1993 - 2022

Table 4.3: Trends of Temperature and Precipitation at Warri South-West

LGA	Test	Temperature	Precipitation
Warri South West	P-value (two-tailed)	**<0.001***	**<0.001***
	Mann-Kendall stat (S)	6.409	-3.746
	Kendall's tau	0.448	-0.177
	Sen's slope	0.015	-17.448
	Trend	Significant increase	Significant decrease

Significant at p<0.05

The focus of the FGD participants was on the effect of the changing precipitation patterns on their livelihood. A male farmer at Ogidigben expressed his thoughts regarding this:

"The change in the climate has also affected our farming activities every year. For example, if you want to plant yams in October, you will have to plan because you do not know the exact time when the rainy season will commence, unlike before".

4.1.1.4 Trend analysis of temperature and rainfall patterns in Brass

The average annual temperature of Brass between 1993 and 2022 was 26.48 °C (Table 4.7), similar to Warri South-West. A statistically significant increase in temperature was observed ($p < 0.05$), with a mean annual increase of 0.012 °C (Table 4.4, Figure 4.7). This trend was accompanied by a Sen slope value of 0.012 (Table 4.4), which indicates an upward trend. The minimum recorded temperature was 26.20°C, and the maximum was 26.95°C, resulting in a narrow range of 0.75°C. Similar to Warri South-West, the standard deviation was 0.21°C, implying low variability in temperature. The skewness of 0.81 shows a slight positive skew, indicating a more frequent higher temperature.

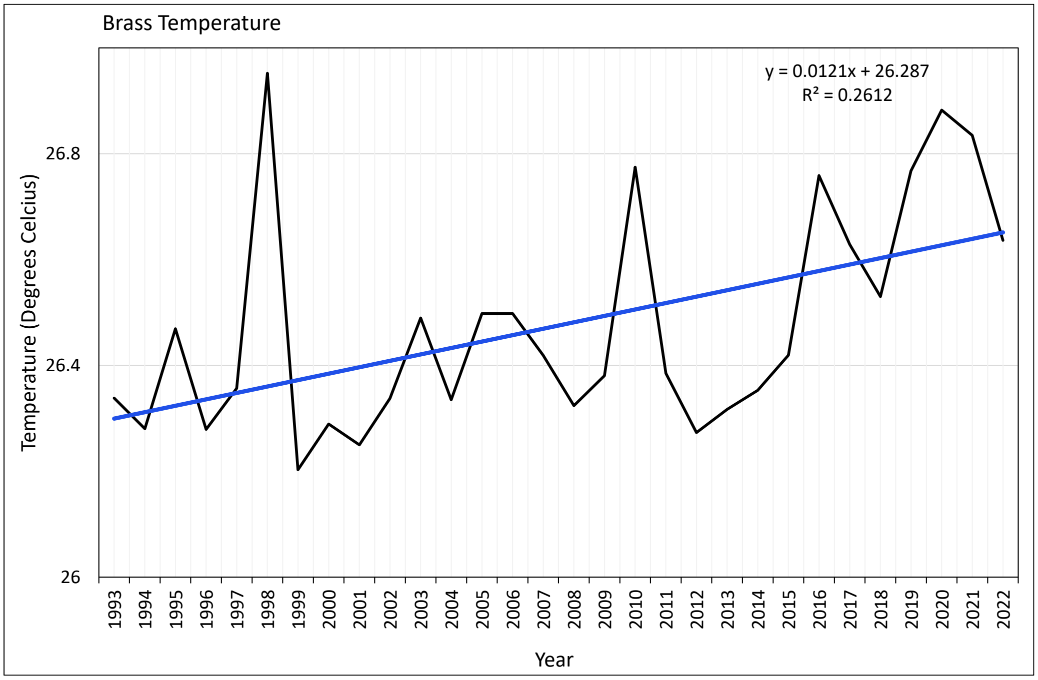


Figure 4.7: Annual Temperature at Brass for the Period 1993 - 2022

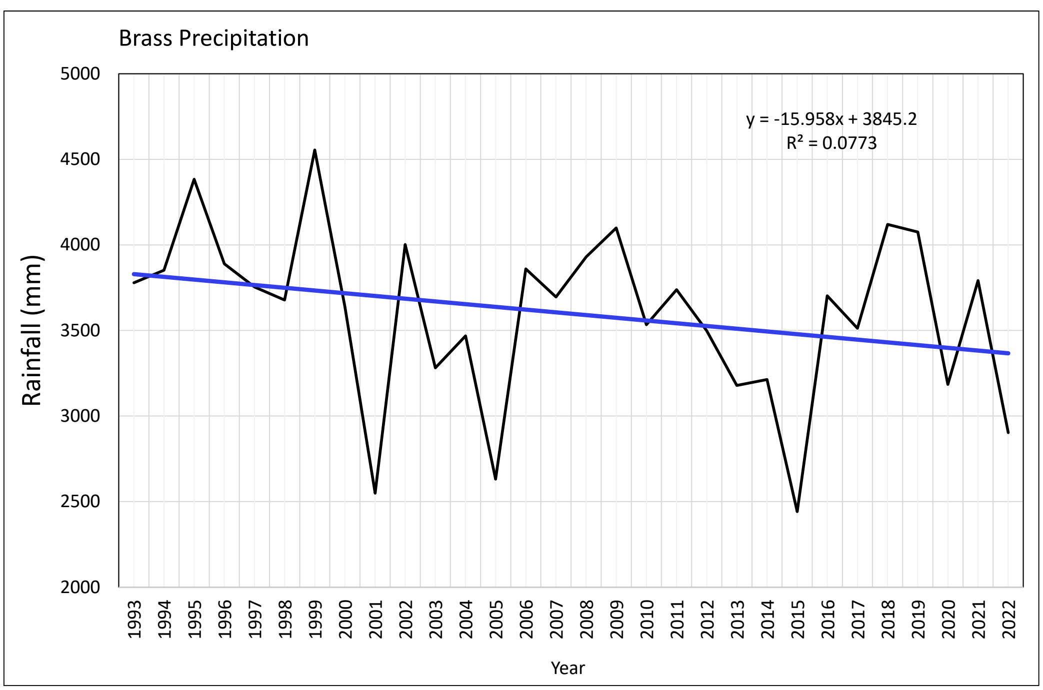


Figure 4.8: Annual Precipitation at Brass for the Period 1993 – 2022

There was a significant downward trend in precipitation ($p < 0.05$), with an annual decrease of 17.36 mm (Table 4.4, Figure 4.8), similar to that of Warri South-West. The average yearly precipitation was 3597.85 mm, indicating the region's high rainfall. The standard deviation was 505.44 mm, indicating substantial interannual variability in rainfall. The minimum recorded annual precipitation was 2441.42 mm, while the maximum was 4554.88 mm, resulting in a range of 2113.46 mm (Table 4.7).

Table 4.4: Trends of Temperature and Precipitation at Brass

LGA	Test	Temperature	Precipitation
Brass	P-value (two-tailed)	**<0.001***	**<0.001***
	Mann-Kendall stat (S)	5.909	-4.123
	Kendall's tau	0.393	-0.200
	Sen's slope	0.012	-17.363
	Trend	Significant increase	Significant decrease

Significant at p<0.05

A female farmer in Twon explained the effect of the rising temperature and significant decrease in rainfall:

"The temperature is high and it affects our plants. The environment is dry. The rain has drastically reduced more than before. The cost of food items is very high"

4.1.1.5 Analysis of sea level rise in Warri South-West

Figure 4.9 shows the plot of the annual sea level rise at Warri South-West. The sea level increased significantly by 3.69 mm per year (Table 4.5) at an average of 58.33 mm at substantial variability (standard deviation = 33.83 mm). This shows a significant increase in sea levels, consistent with global trends observed in recent decades due to climate change. The minimum recorded sea level rise was 9.67 mm, and the maximum was 127.58 mm, resulting in a wide range of 117.92 mm. The skewness of 0.31 showed a slight positive skew, meaning there are more years with higher-than-average sea level rise (Table 4.7).

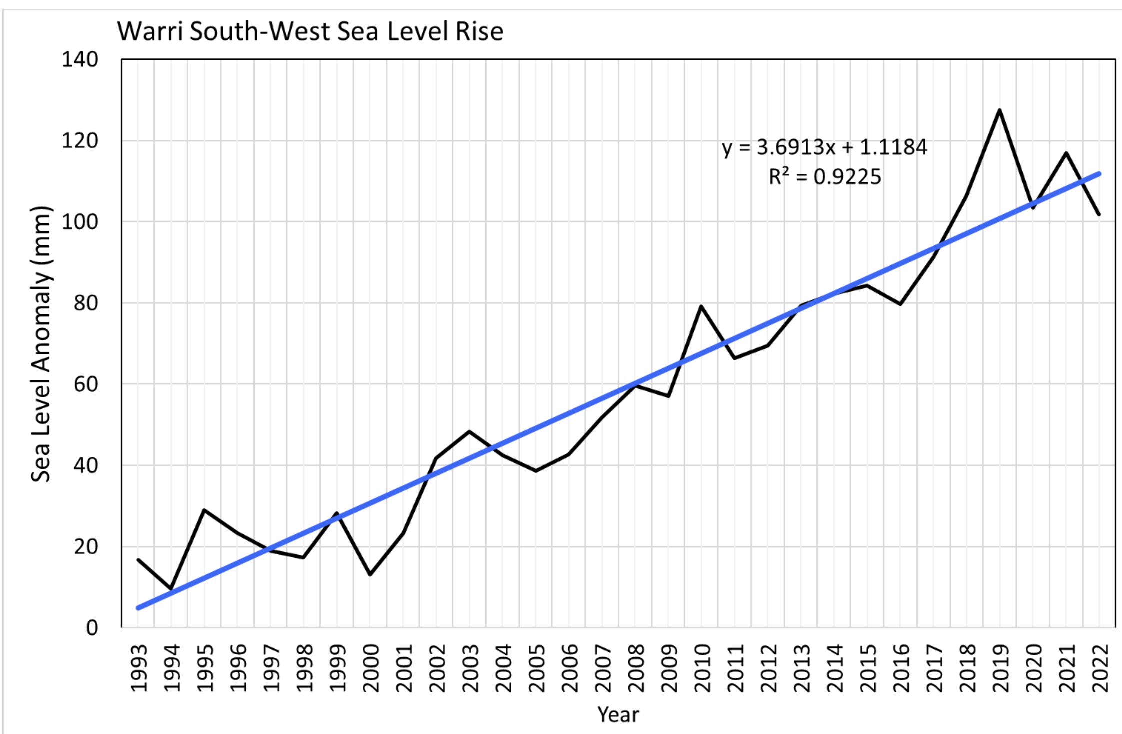


Figure 4.9: Annual Sea Level Rise at Warri South-West for the Period 1993 – 2022

Table 4.5: Trends of Sea Level Rise at Warri South-West

Test	Sea Level Rise
P-value (two-tailed)	**<0.001***
Mann-Kendall stat (S)	9.218
Kendall's tau	0.502
Sen's slope	3.691
Trend	Significant increase

Significant at p<0.05

An FGD participant at Ugborodo emphasised the influence of the changing climate and environment on their well-being:

"Our means of livelihood has been affected. Farming has stopped to a large extent. The main occupation here was farming and fishing but sea level rise has stopped people from going to farm."

4.1.1.6 Analysis of sea level rise in Brass

Figure 4.10 shows the plot of the annual sea level rise in Brass. The sea level increased significantly by 3.58 mm per year (at $p < 0.05$) (Table 4.6). Over 30 years, the average sea level anomaly was 46.48 mm at a standard deviation of 30.63 mm. The minimum recorded sea level rise was 2.83 mm, and the maximum was 112.33 mm, resulting in a range of 109.50 mm. The skewness of 0.73 showed a positive skew, meaning there are more years with higher-than-average sea level rise (Table 4.7).

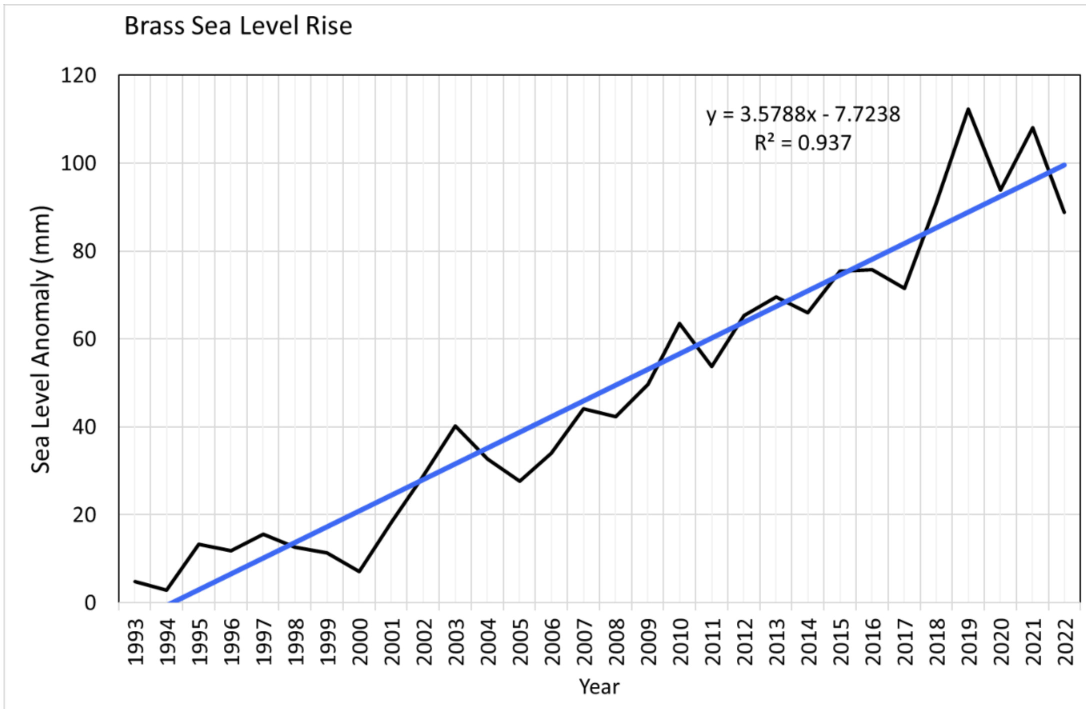


Figure 4.10: Annual sea level rise at Brass for the period 1993 - 2022

A male fisherman at Twon decried the adverse effects of the rising sea level in his community:

"The sea level rise has affected our fishing boats, jetties and buildings. It has also affected the yield of fish catch and the cost of feeding our families. Our livelihood has been severely affected".

A similar experience was shared at Odioma. A male fisherman had this to say:

"We no longer experience fish yields before, due to the rise in sea tides (sea level). Fishes are now more expensive than ever and people now opt for crayfish. We no longer see some species of fish again"

Table 4.6: Trends of sea level rise at Brass

Test	Sea Level Rise
P-value (two-tailed)	**<0.001***
Mann-Kendall stat (S)	9.210
Kendall's tau	0.482
Sen's slope	3.579
Trend	Significant increase

Significant at p<0.05

Table 4.7: Summary of Descriptive Statistics of Climate Indicators at Migration Origins

LGA	Parameter	Years	Mean	SD	Median	Min	Max	Range	Skew	Kurtosis	SE
Kano Municipal	Precipitation	30	863.10	102.75	854.65	702.58	1092.27	389.69	0.32	-0.98	18.76
	Temperature	30	26.41	0.39	26.47	26.64	27.10	1.46	-0.12	-0.78	0.07
Kwali	Precipitation	30	1166.19	120.86	1163.54	724.59	1372.22	647.63	-1.22	3.74	22.07
	Temperature	30	28.50	0.36	28.51	27.81	29.33	1.52	0.22	-0.47	0.07
Warri South West	Precipitation	30	3367.98	456.06	3424.22	2463.66	4278.96	1815.30	-0.02	-0.66	83.27
	Temperature	30	26.42	0.21	26.37	26.16	26.84	0.68	0.71	-0.85	0.04
	Sea level rise	30	58.33	33.83	54.38	9.67	127.58	117.92	0.31	-1.01	6.18
Brass	Precipitation	30	3597.85	505.44	3698.97	2441.42	4554.88	2113.46	-0.58	-0.11	92.28
	Temperature	30	26.48	0.21	26.40	26.20	26.95	0.75	0.81	-0.63	0.04
	Sea level rise	30	46.48	30.62	42.33	2.83	112.33	109.50	0.73	-0.63	5.59

4.1.1.7 Examining ecological health indicators in areas of origin

(a) Analysis of vegetation patterns in Kano Municipal

In 2003, the NDVI value over Kano Municipal was 0.306, gradually decreasing to 0.198 in 2022 (Figure 4.11). It significantly reduced by 0.01 per year ($p < 0.05$), with an average value of 0.24 over the 20 years. This was confirmed by the Sen's slope value of -0.005 (Table 4.8), indicating a downward trend. The standard deviation was 0.04, implying relatively low variability in annual NDVI values. The minimum and maximum recorded NDVI values were 0.20 and 0.31, respectively, signifying a range of 0.11 (Table 4.9). There was a period of healthy vegetation between 2003 and 2007, then unhealthy vegetation between 2008 and 2009 (Figure 4.12). There was a brief recovery to healthy vegetation between 2010 and 2012. 2013 to 2022 witnessed unhealthy vegetation, except for 2017 and 2018, where normal vegetation was observed. This emphasises the significant downward trend of vegetation at Kano Municipal as shown in Figure 4.11.

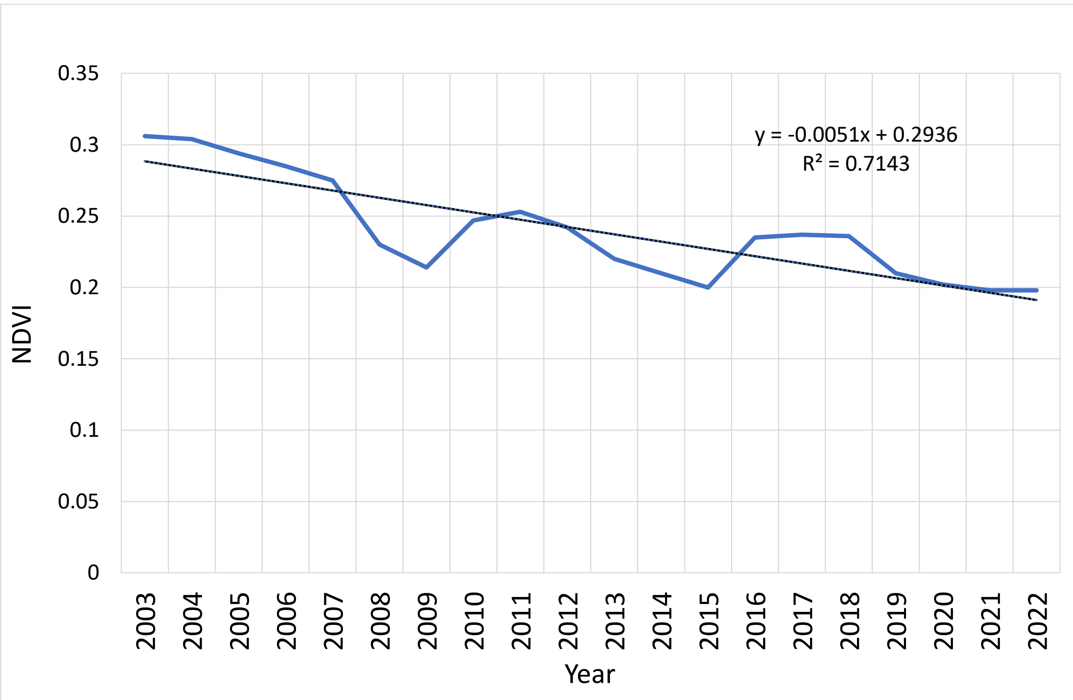


Figure 4.11: NDVI Time Series at Kano Municipal for the Period 2003 - 2022

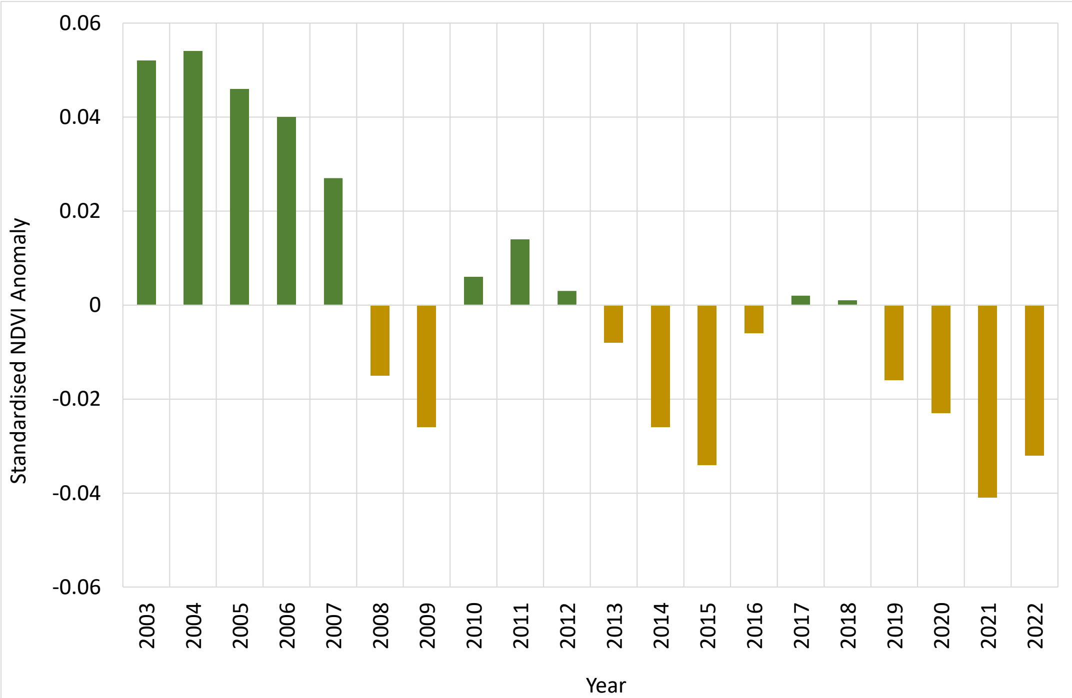


Figure 4.12: Standardised NDVI Anomaly at Kano Municipal for the Period 2003 - 2022

(b) Analysis of vegetation pattern in Kwali

There was a significant decreasing trend of NDVI at Kwali (Sen's slope = -0.003, ($p < 0.05$), decreased by 0.0031 every year (Table 4.8). The average NDVI over the 20 years is 0.39. Intermittent periods of healthy and less healthy vegetation were between 2003 and 2022. For example, between 2003 and 2011, Kwali experienced healthy vegetation but negative anomalies in 2005, 2007 and 2008 (Figure 4.13). Less healthy vegetation was observed between 2012 and 2015. 2016 to 2018 had healthy vegetation while 2019 to 2022 (except for 2020) had unhealthy vegetation, connoting moderate to high vegetation density, suggesting healthy vegetation cover in Kwali. The standard deviation is 0.07, implying moderate variability in annual NDVI values. The minimum recorded NDVI is 0.27, and the maximum is 0.53, resulting in a range of 0.26 (Table 4.9). There were intermittent periods between healthy vegetation and unhealthy vegetation with more years of unhealthy vegetation between 2012 and 2022 (Figure 4.14) which accounted for the decreasing trend in vegetation in Figure 4.13.

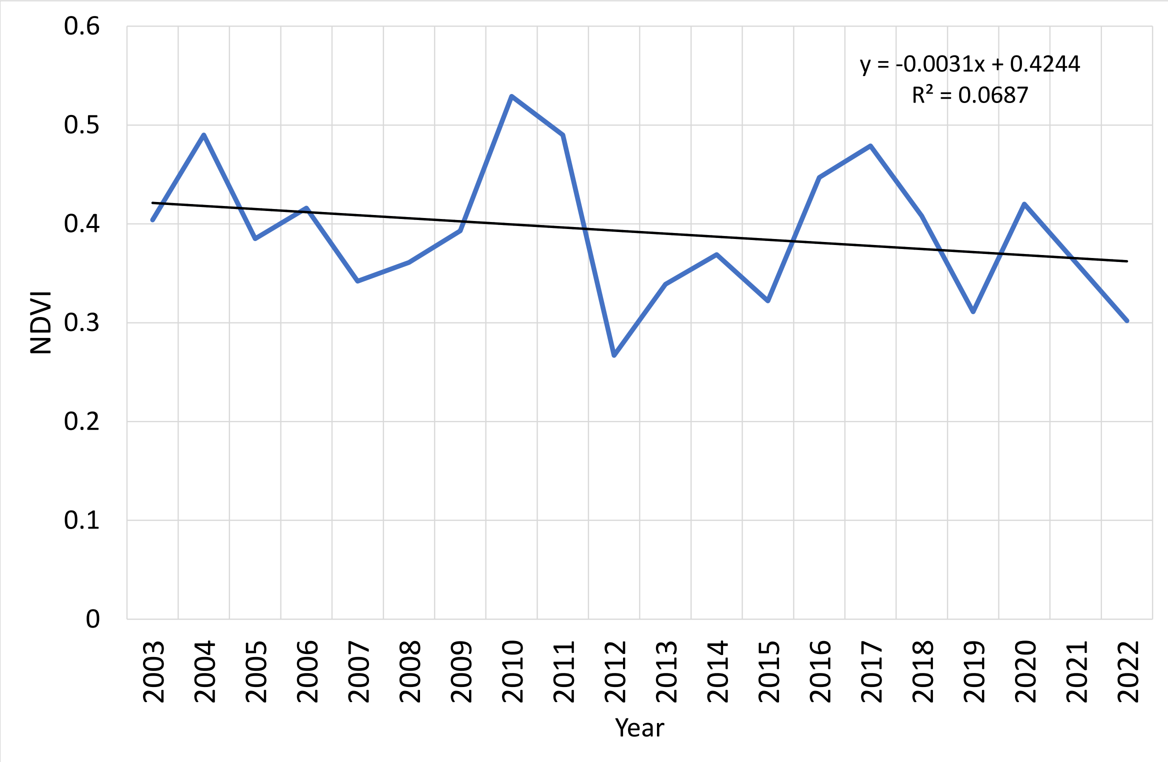


Figure 4.13: NDVI Time Series at Kwali for the Period 2003 - 2022

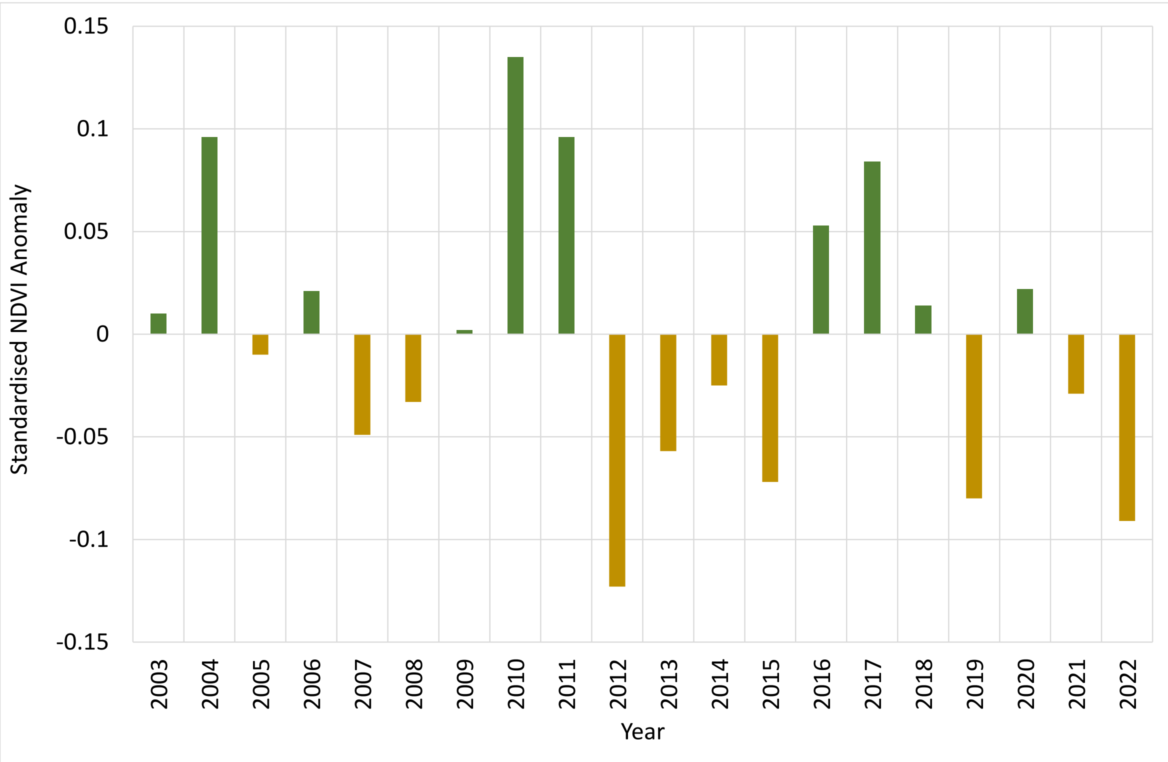


Figure 4.14: Standardised NDVI Anomaly at Kwali for the Period 2003 - 2022

(c) Analysis of vegetation pattern in Warri South-West

The annual NDVI values over Warri South-West significantly decreased by 0.004 per year (Sen's slope = -0.004. $p < 0.05$) (Table 4.8). The average NDVI over the 20 years was 0.18. 2003 to 2010 had very healthy vegetation (except 2009) (Figure 4.16). 2009 to 2022 had less healthy vegetation (except for 2020 and 2021). The significant decrease in the NDVI values might suggest an increase in drought frequency at the locations of origin (Figure 4.15). The standard deviation is 0.05, implying moderate variability in annual NDVI values. The minimum recorded NDVI is 0.12, and the maximum is 0.28, resulting in a range of 0.16. The average NDVI of 0.18 suggested relatively low vegetation density (Table 4.9).

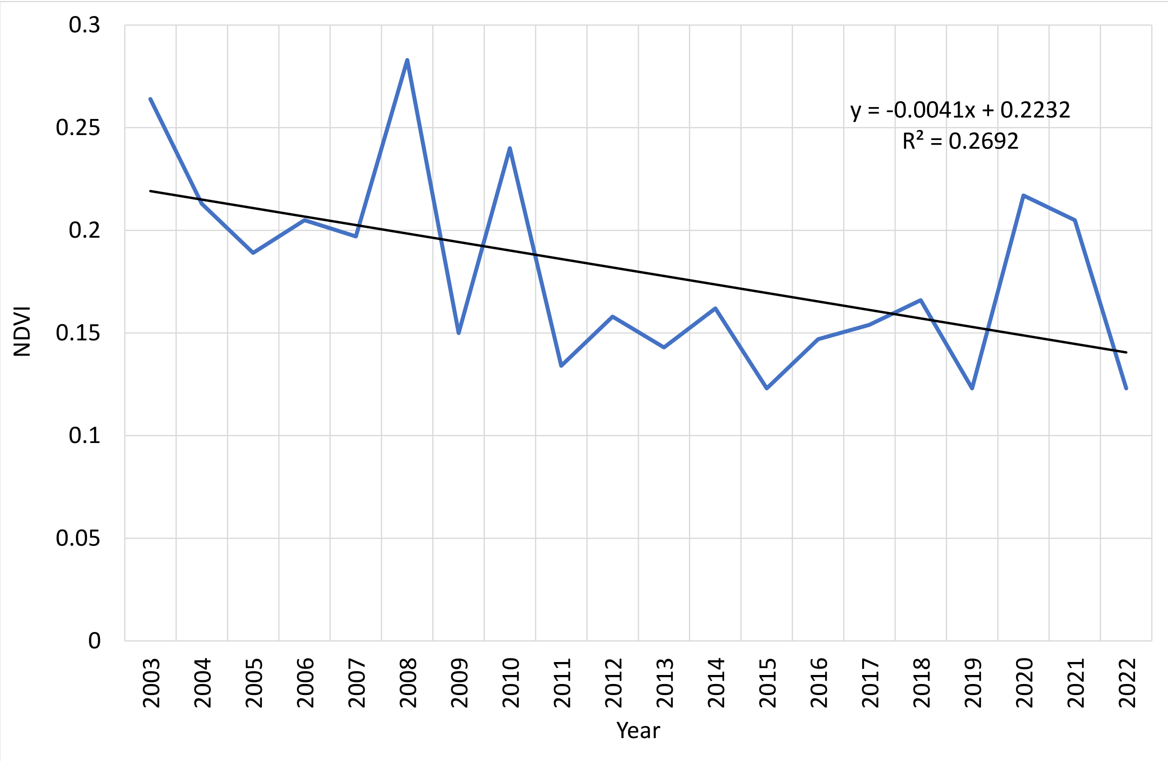


Figure 4.15: NDVI Time Series at Warri South-West for the Period 2003 - 2022

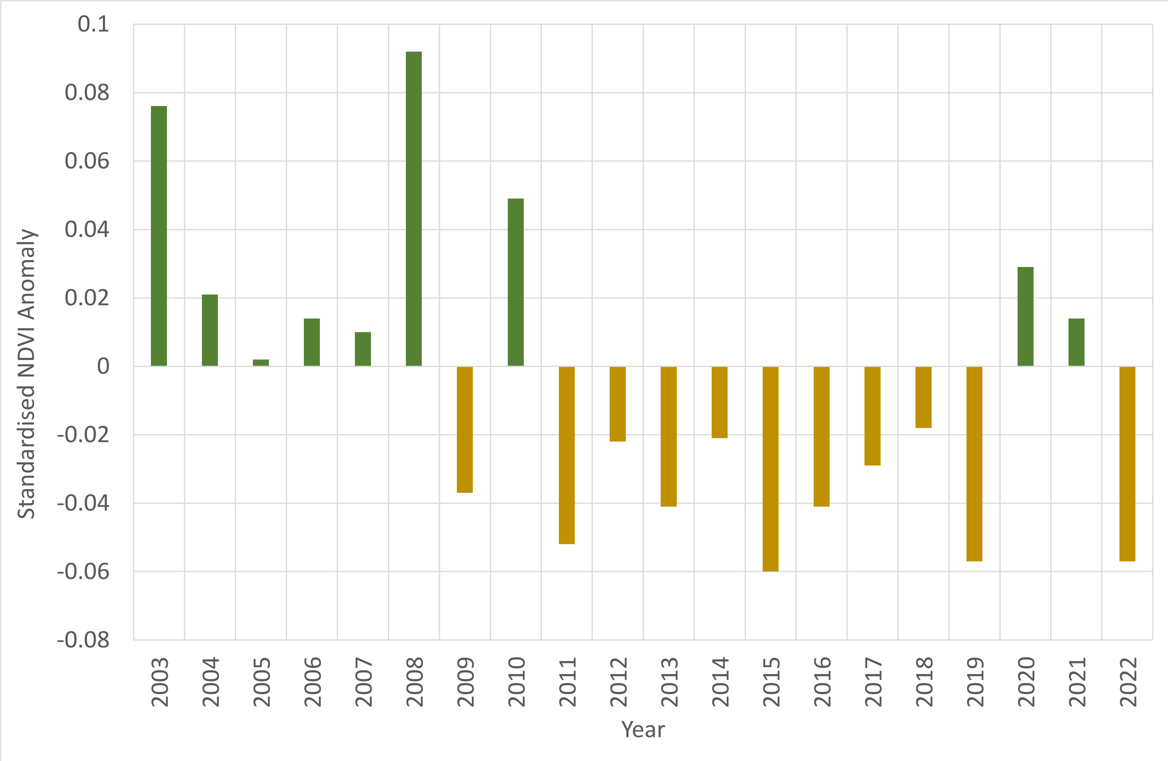


Figure 4.16: Standardised NDVI Anomaly at Warri South-West for the Period 2003 – 2022

(d) Analysis of vegetation pattern in Brass

The annual NDVI values in Brass decreased by 0.003 per year, but not significantly (p = 0.0199) (Table 4.8). 2004 to 2017 witnessed unhealthy vegetation except for 2008, 2010 and 2012 (Figure 4.18). The average NDVI over the 20 years was 0.16, reflecting relatively low vegetation density, like Warri South-West, and characteristic of regions facing significant environmental pressures. The standard deviation was 0.05, reflecting moderate variability in annual NDVI values (Table 4.9).

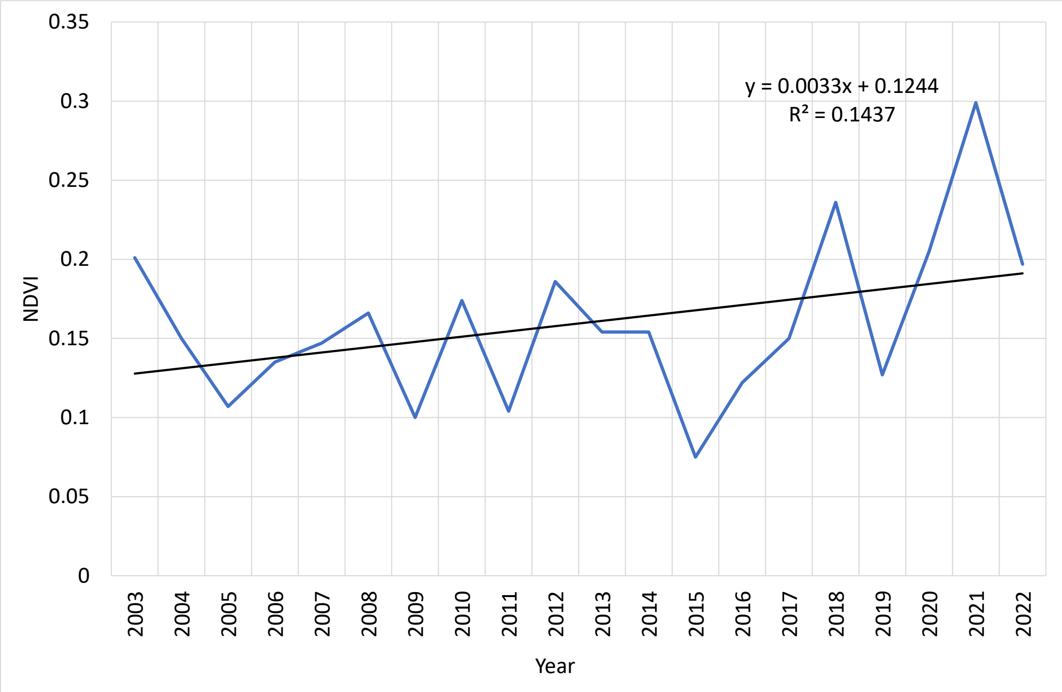


Figure 4.17: NDVI Time Series at Brass for the Period 2003 - 2022

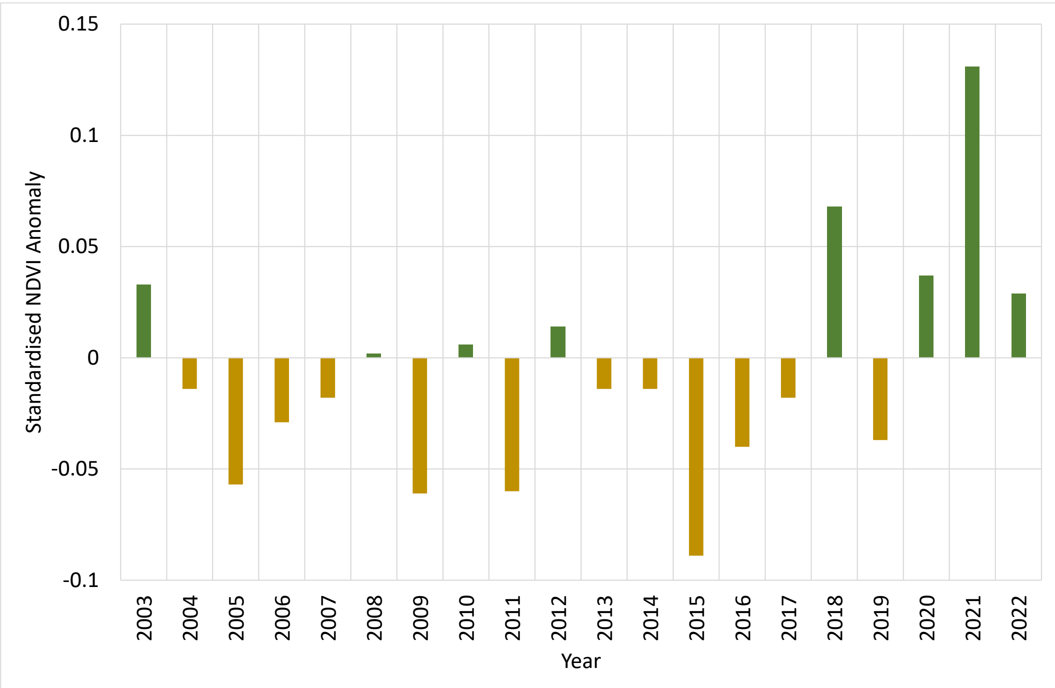


Figure 4.18: Standardised NDVI Anomaly at Brass for the Period 2003 - 2022

Table 4.8: Summary of Trend Analysis of Ecological Health Indicators at Migration Origins

LGA	Mean	SD	Median	Min	Max	Range	Skew	Kurtosis	SE
Kano Municipal	0.24	0.04	0.24	0.20	0.31	0.11	0.55	-1.08	0.01
Kwali	0.39	0.07	0.39	0.27	0.53	0.26	0.22	-0.93	0.02
Warri South West	0.18	0.05	0.16	0.12	0.28	0.16	0.59	-0.76	0.01
Brass	0.16	0.05	0.15	0.08	0.30	0.22	0.77	0.46	0.01

Table 4.9: Summary of Descriptive Statistics of Ecological Health Indicators at Migration Origins

LGA	P-Value (Two-Tailed)	Mann-Kendall Stat (S)	Kendall's Tau	Sen's Slope	Trend
Kano Municipal	**<0.001***	-6.1704	-0.7053	-0.006	Significant decrease
Kwali	**<0.001***	-3.6395	-0.2000	-0.003	Significant decrease
Warri South West	**<0.001***	-4.2107	-0.3368	-0.0044	Significant decrease
Brass	0.0199	2.3285	0.2105	0.0027	Not significant

Significant at p<0.05

4.1.1.8 Examining the existence of drought in areas of origin

(a) Drought monitoring in Kano Municipal

In addition to the analysis of standardised NDVI anomaly, the Vegetation Condition Index (VCI) was analysed alongside the SPI to determine periods of good vegetation health and drought. The VCI and SPI are critical indicators of drought and overall vegetation health. Analysing the annual SPI and VCI from 2003 to 2022 for Kano Municipal provides valuable insights into the area's drought patterns. From 2003 to 2022, the VCI in Kano Municipal exhibited fluctuations, reflecting varying levels of vegetation health and drought conditions over the years (Figure 4.19). The VCI values for the early part of the period were relatively low, with a notable dip in 2003 at 22.6, rising to 28.1 in 2004, then fluctuating around the range of 20 and 30, indicating moderate drought conditions.

Between 2008 and 2017, a mix of low and moderately high VCI values. The lowest VCI value in 2008 was 23.4, while 2016 showed a significant improvement, with a VCI of 31.9. This period reflects a cycle of recovery and stress, with periods of drought interspersed with years of vegetation recovery. The most remarkable observation was the increase in VCI in 2018, peaking at 45.3. The spike indicates a year of exceptional vegetation health. Following this peak, the VCI values remained relatively high compared to the earlier years, with a minor decline but above 30 in most subsequent years, indicating improved and more stable vegetation conditions.

While there was no evidence of extreme drought, several years experienced severe drought, including 2003, 2005, 2007, 2008, 2009, 2011, 2013, 2014, and 2015. These years represent periods of significant drought stress affecting vegetation, whereas years such as 2004, 2006, 2010, 2012, 2016, 2017, 2019, 2020, and 2021 experienced mild drought. 2018 was the only year with no drought. According to the SPEI analysis, 2007 was the only year with severe drought. 2000, 2006, 2009, and 2014 had periods of moderate drought, while other years were near normal and moderately wet (Figure 4.20).

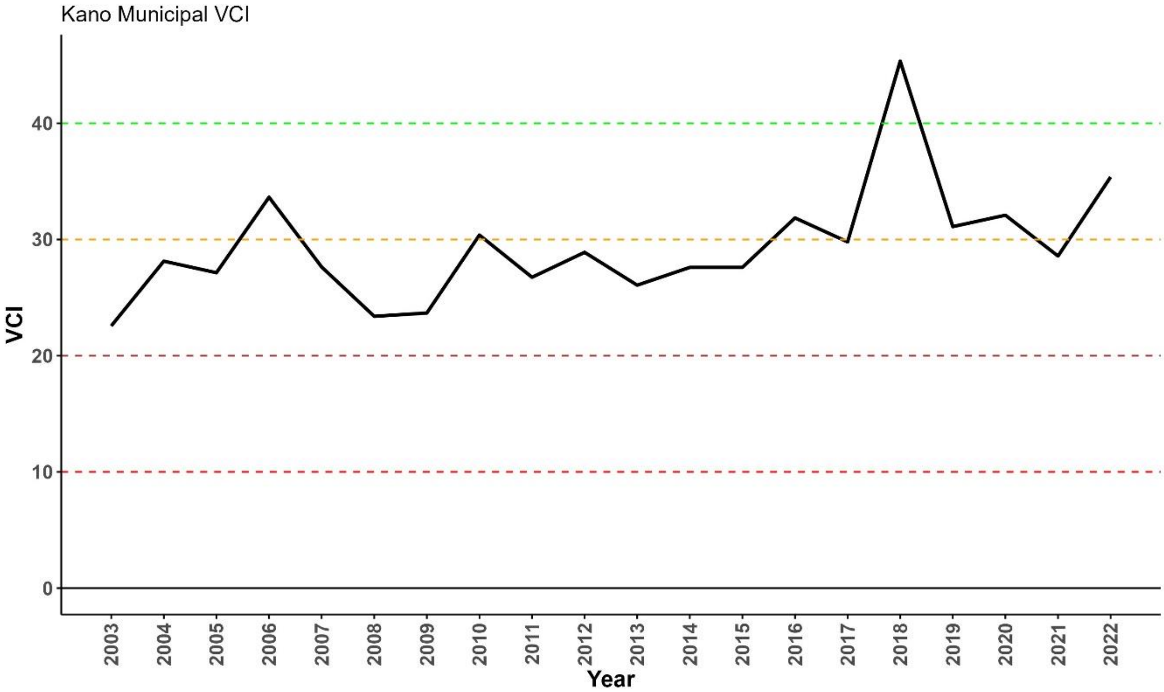


Figure 4.19: Variation of Vegetation Condition Index at Kano Municipal

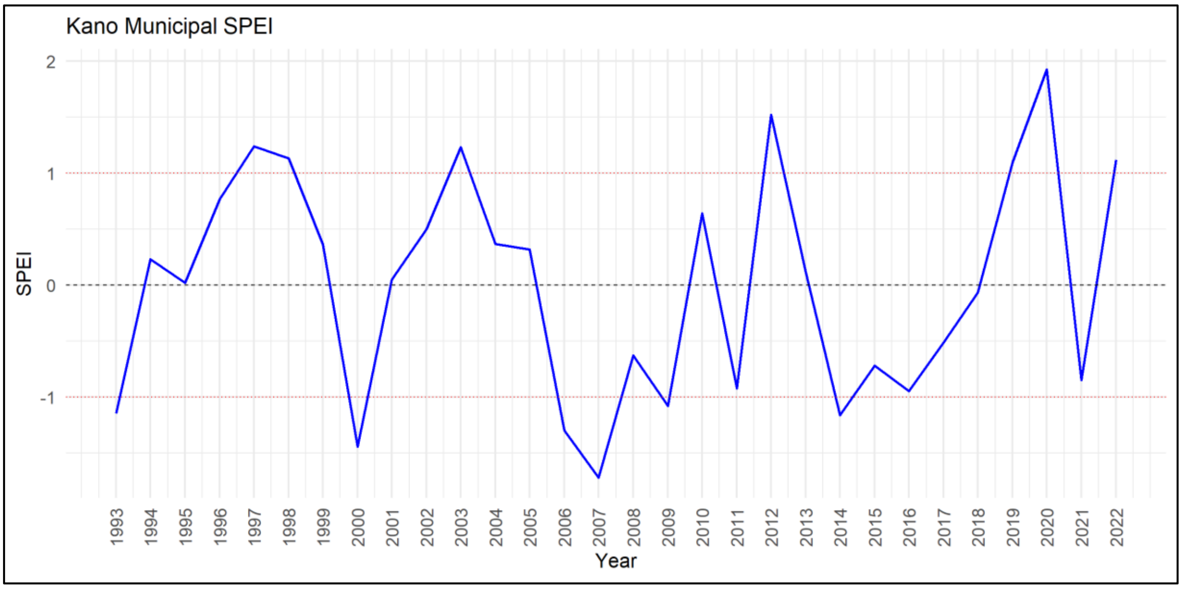


Figure 4.20: Variation of Dry and Wet Years at Kano Municipal

(b) Drought monitoring in Kwali

The VCI data for Kwali from 2003 to 2022 revealed noteworthy fluctuations, reflecting the region's dynamic climatic conditions and vegetation response (Figure 4.21). The early years (2003-2008) showed a general decline in VCI from 48.6 in 2003 to 42.6 in 2006. This decline gave insight into deteriorating conditions and vegetation stress. Between 2009 and 2013, there was a noticeable improvement in the VCI values, peaking at 49.6 in 2013. There was more variability from 2014, ranging from a low of 40.4 in 2021 to highs like 48.6 in 2016 and 47.4 in 2020. The recent decline in VCI values, particularly from 2017 to 2021, reflects increasing vegetation stress. However, there was a recovery in 2020 with a VCI value of 47.4. Generally, Kwali experienced no drought conditions according to the VCI values. According to the SPEI analysis, 2013 was the only year where severe drought was experienced. Other years were in near-normal conditions and wet years (Figure 4.22).

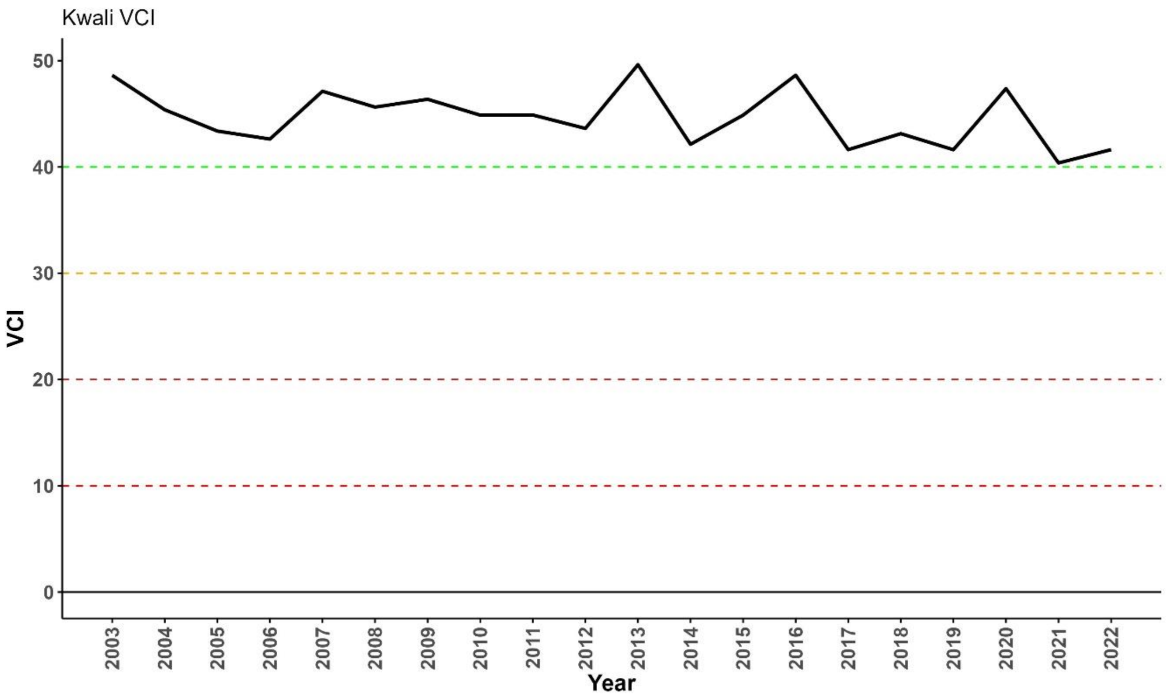


Figure 4.21: Variation of Vegetation Condition Index at Kwali

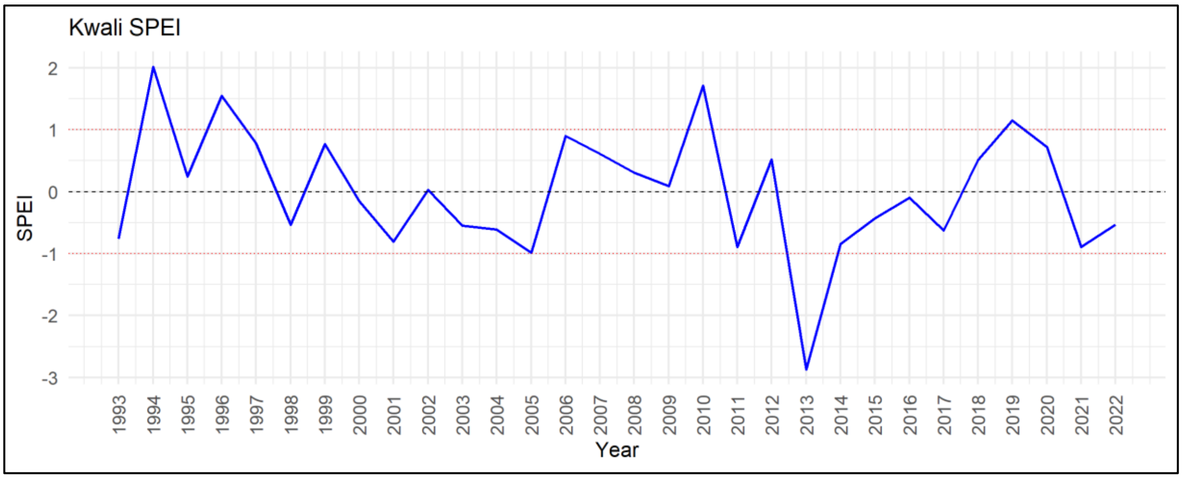


Figure 4.22: Variation of Dry and Wet years at Kwali

(c) Drought monitoring in Warri South-West

At Warri South-West, the early years showed fluctuations in VCI values, starting at 40.3 in 2003 and reaching a peak of 41.3 in 2008, with the narrow range characterising moderate variability (Figure 4.23). The dip from 2005 to 35.8 indicates periods of vegetation stress. Between 2009 and 2013, the VCI declined slightly. The VCI decreased to 35.7 in 2009 and 32.3 in 2012, indicating years of increased vegetation stress. However, the subsequent recovery to 38.7 in 2013 indicates a temporary improvement. The period from 2014 onwards showed increased variability in VCI values. The VCI ranged from a low of 28.7 in 2016 to a high of 35.7 in 2015. The subsequent years show fluctuating VCI values, with a general decline toward the end of the period, reaching 31.7 in 2022.

This recent decline revealed persistent vegetation stress, possibly due to ongoing climatic challenges or environmental degradation. The periods of 2003 and 2008 were the only periods with no drought. Other years saw mild droughts, except for 2016 when a moderate drought was observed. According to the SPEI analysis, 2001 and 2015 were severe drought years. Moderate droughts occurred in 2005, 2013, and 2020. The other years were near normal and wet periods (Figure 4.24).

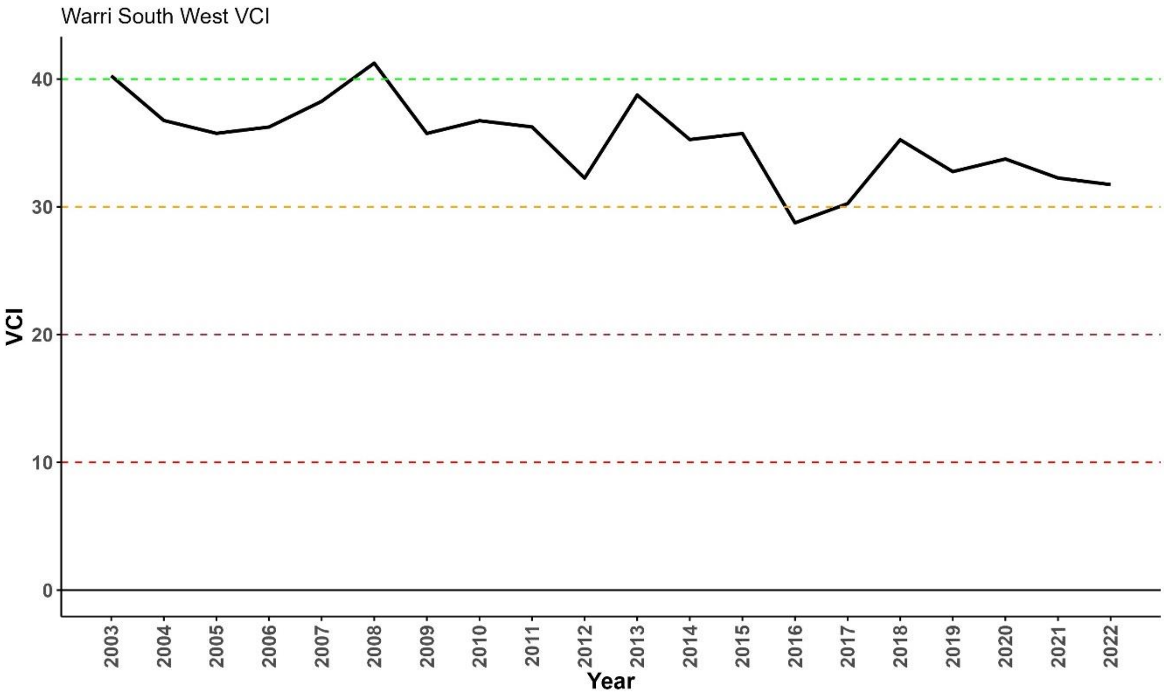


Figure 4.23: Variation of Vegetation Condition Index at Warri South-West

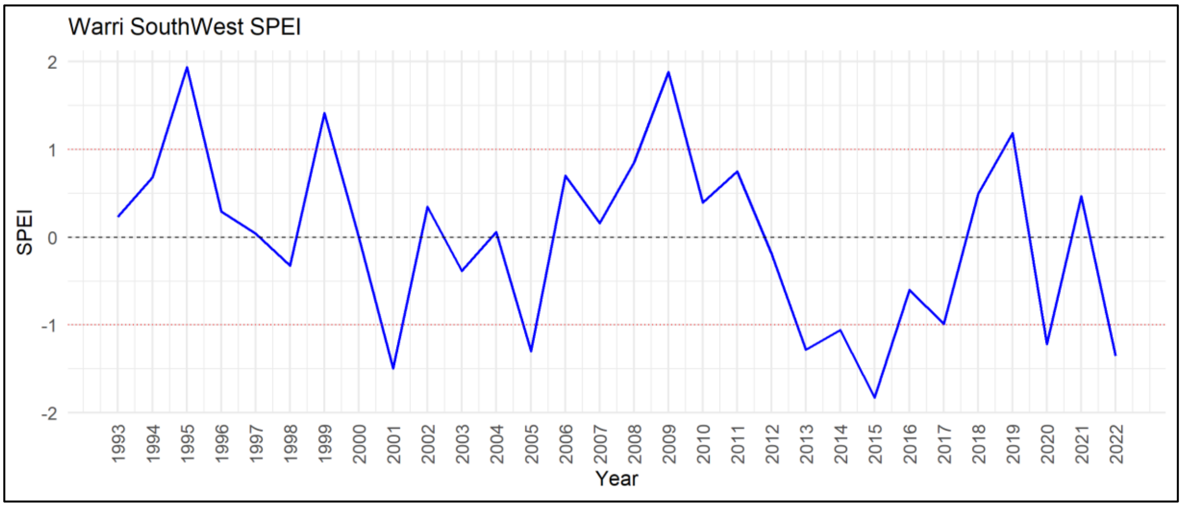


Figure 4.24: Variation of Dry and Wet Years at Warri South-West

(d) Drought monitoring in Brass

There were alternating years of healthy and unhealthy vegetation conditions at Brass, starting at 38.3 in 2003, the VCI declined to 33.3 in 2004 before recovering to 36.3 in 2005 and peaking at 40.8 in 2008 (Figure 4.25). Between 2009 and 2013, the VCI values generally declined, with a notable low of 30.8 in 2012. This suggests a period of increased vegetation stress, followed by a partial recovery in 2013 with a VCI of 35.7. The period from 2014 to 2022 showed increased variability in VCI values, dropping to a low of 29.8 in 2014. However, there was a recovery in subsequent years, with values getting 40.3 in 2021 but dropping to 36.3 in 2022. All the years were in the category of mild drought, aside from 2008, 2020 and 2021 which were not drought years, and 2014 which had moderate drought. The SPEI analysis revealed severe drought conditions during the years 2001, 2005, 2015 and 2022. Moderate drought occurred in 2003, 2013, and 2020. Other years were near normal and wet periods (Figure 4.26).

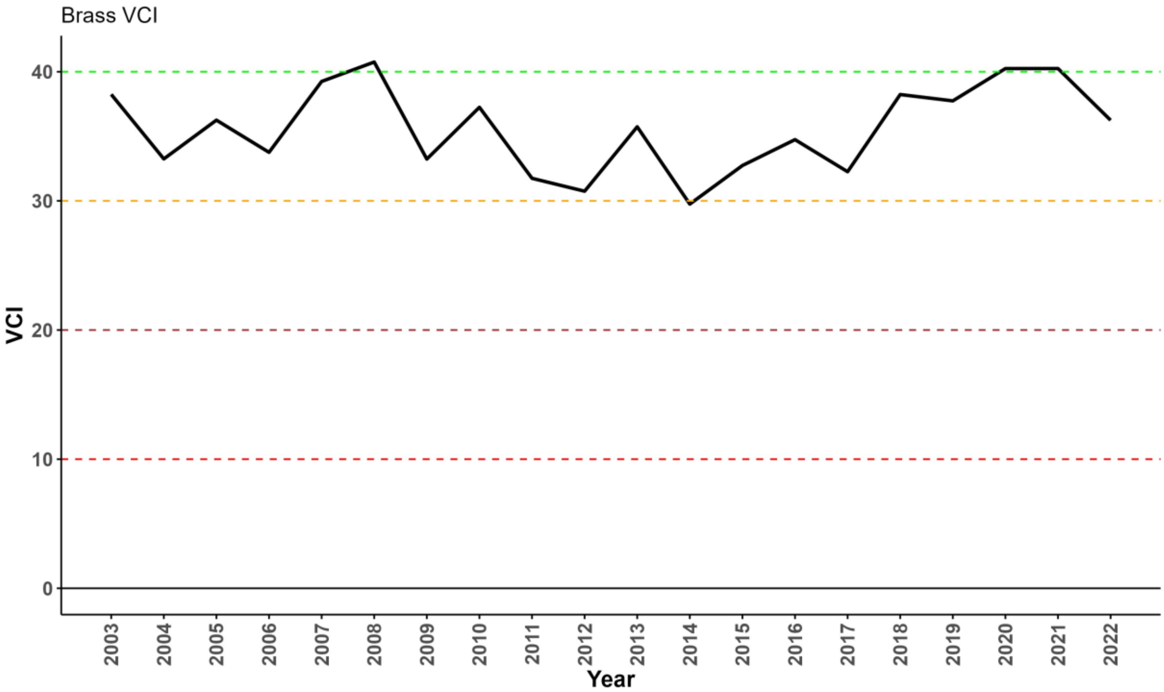


Figure 4.25: Variation of Vegetation Condition Index at Brass

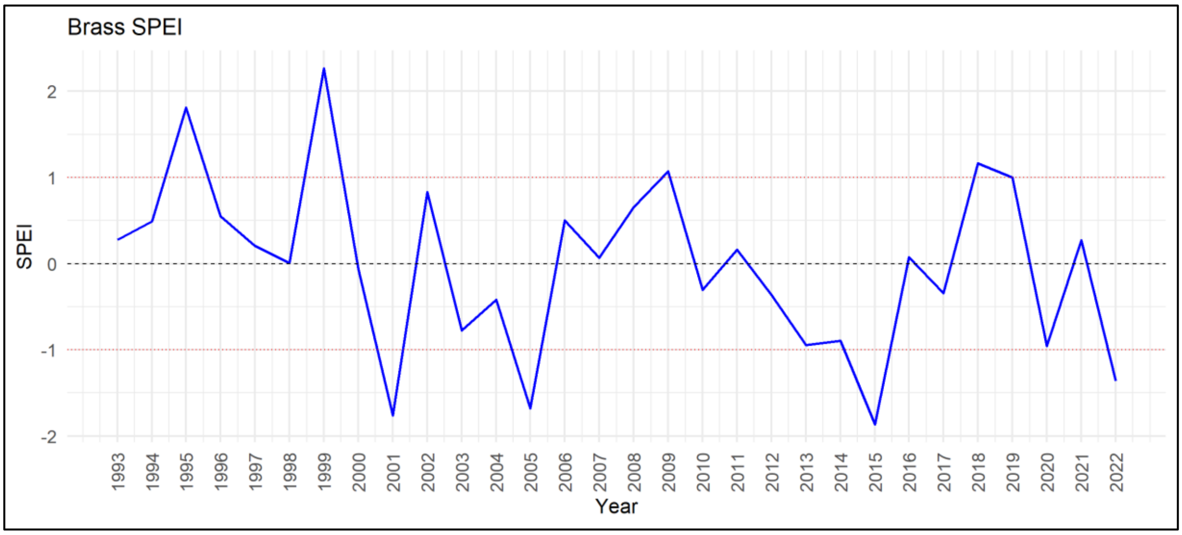


Figure 4.26: Variation of Dry and Wet Years at Brass

4.1.1.9 Assessing environmental/climatic factors affecting households in communities of migration origin

Households are usually impacted by environmental and climatic factors, such as drought, floods, sea level rise, temperature increase, and varying precipitation. The environmental and climatic factors affecting households of migration origin in communities are presented in Figure 4.27. Over 85 percent of households in communities of migration origin reported no climatic impact in Tudun Nufawa, Zuba, Tungamaje, and Central (where 96.7 percent of households were unaffected by climate or environmental issues). Drought was a major challenge in Zango, where 34.4 percent of households were affected. Respondents from Zango and Wako households were affected by 64.4 percent and 57.8 percent, respectively. Rising sea levels affect coastal communities, with 87.8 percent of Odioma households affected by rising sea levels. Respondents from Twon, Ogidigben, and Ugborodo also claimed that 52.2 percent, 62.3 percent, and 62.2 percent, respectively, of their households were affected by the effects of sea level rise.

On average, most respondents were unaffected by any climatic/environmental event (Figure 4.28). Among the stated events, most respondents were affected by sea level rise in the coastal areas, followed by floods experienced in almost every location, and drought, which was predominant in Zango.

The thematic analysis of FGDs revealed that environmental and climatic factors such as temperature, precipitation, floods, and sea level rise affect the daily lives and economic activities of households in these communities (Table 4.10). The responses highlight the communities' challenges and the attempted adaptive strategies to address these issues. Addressing these issues requires targeted interventions that consider the unique circumstances of each community.

There was a significant variation in the perception of environmental and climatic factors affecting households across the communities ($H = 281.668$, $p < 0.05$) (Table D1). The post hoc test identified significant pairwise variation between the communities. The significant variations among the communities are illustrated in Table D2.

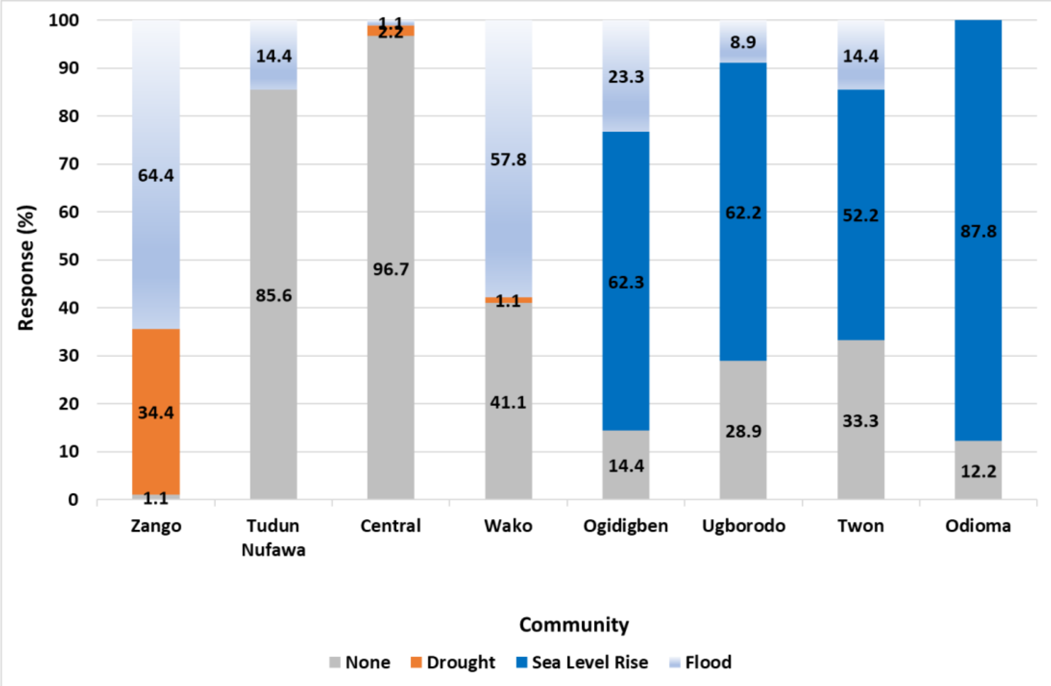


Figure 4.27: Environmental/climatic Events Affecting Households in Communities of Migration Origin

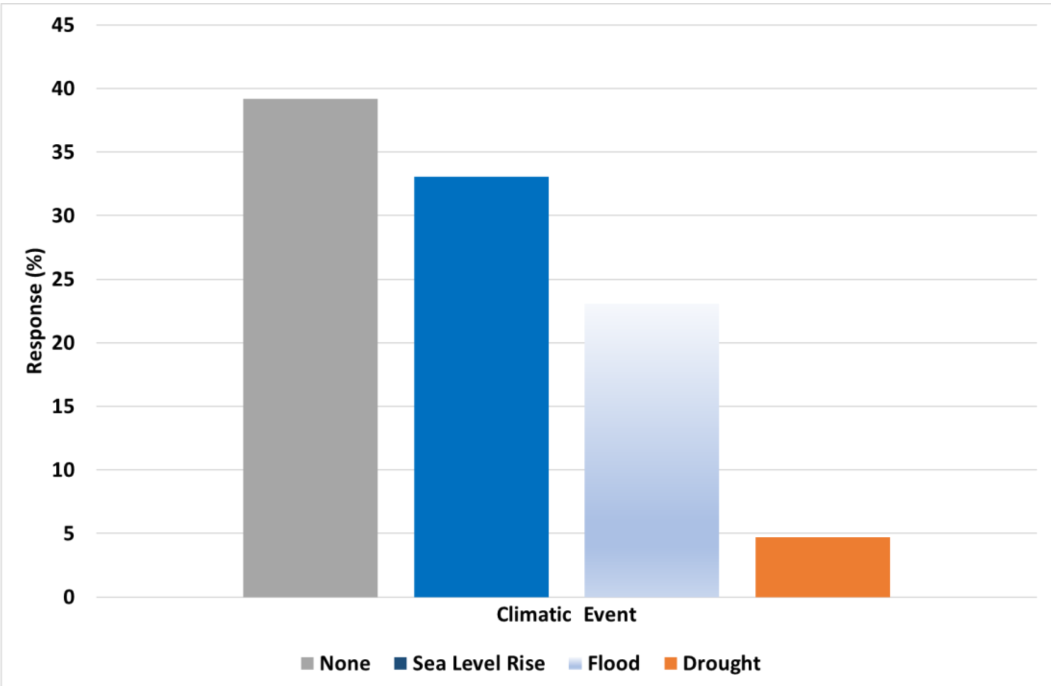


Figure 4.28: Ranking of Environmental/Climatic Events Affecting Households in Communities of Migration Origin

Table 4.10: Emerging Themes of Environmental/Climatic Factors Affecting Households in Communities of Migration Origin

Theme	Community	Extracts of Participants' Responses
Temperature	Zango	Temperature has increased in the past decades due to the developments around us. It increases the prevalence of malaria. They resort to alternative power supply for cooling.
	Tudun Nufawa	Affected by high temperatures. They sit in tree shades during the day and use cooling fans at night
	Wako	The lack of a constant electric power supply for cooling makes coping with extreme temperatures difficult. Temperature rise increases the risk of malaria and measles.
	Twon, Odioma	The high temperature affects plants and health (especially) malaria and heat rashes. They are used to it.
Precipitation	Zango	The rains have increased over time. They experience more erosion and flood events.
	Ogidigben, Ugborodo, Twon, Odioma	Farming activities and yields are affected by the fluctuating rainfall patterns. The rainfall is very difficult to predict in recent times.
Floods	Zango	We experience floods due to poor drainage systems and building structures along drainage systems.
	Tudun Nufawa	The flood affects us, but we find ways to manage the situation.
Sea level rise	Ogidigben, Ugborodo	The floods from the sea expose our elders to cold and diseases. It has washed our way our farms, and our roads. Our people cannot go to the farm again.
	Twon, Odioma	The sea level rise affects our livelihoods, boats and buildings. It also affects our fish catch.

4.1.2 Socio-demographic characteristics of the respondents

4.1.2.1 Gender distribution of household heads

Gender remains a crucial factor in migration discourse. The gender distribution of the respondents reveals a predominance of male household heads across all LGAs. In Kano Municipal LGA, 91.7 percent of the household heads were male, while only 8.3% were female (Table C). This was similar in other locations such as Fagge (81.7 percent male, 8.3 percent female), and Kwali (80.0 percent male, 20 percent female) LGAs.

The major representation of males as household heads reflects the patriarchal structure in Nigerian societies, where men are traditionally regarded as the primary decision-makers, being the household heads. However, there were considerable female representations across the LGAs, such as in Gwagwalada LGA (57.2 percent female, 42.8 percent male), Warri South-West LGA (57.8 percent female, 42.2 percent male), and Brass LGA (51.7 percent female, 48.3 percent male).

4.1.2.2 Age distribution of household heads

The findings from the age distribution analysis of the respondents reveal that most household heads fall within the economically active age range of 26 to 65 years, with a notable proportion aged between 46 and 55 years (Table C). This is consistent with the expectation that household heads are individuals with viable livelihoods and ability to make household decisions. This is evident across all LGAs, with Kano Municipal where 35.6 percent of respondents were aged 56-65 years and 29.4 percent of the household heads were in the 36–45-year bracket. Meanwhile, 31.1 percent of the household heads at Fagge were between 36-45 years, closely followed by the age bracket of 45-55 years (27.2 percent) and 26-35 years (22.8 percent). Most of the household heads at Gwagwalada were between 36-45 years (37.2 percent) and 26-35 years (26.7 percent). At Kwali, there was an equal age range distribution of 26-35 years and

36-45 years at 32.8 percent each. A similar situation was observed at Warri South-West with the same age distribution equaling 32.2 percent each. However, it was different at Brass where most household heads were between 36-45 years (46.1 percent).

The relatively low representation of younger respondents (16-25 years) and older respondents (above 65 years) further underscores the role of middle-aged individuals as the primary decision-makers in households. For example, in Kano Municipal LGA, 3.3 percent of the household heads were above 65 years old, which was the lowest proportion. The same could be said of Fagge 0.6 (percent), Gwagwalada and Warri South-West (both at 1.1 percent), Kwali (2.2 percent), and Brass (5 percent).

4.1.2.3 Marital status of household heads

Marital status plays a fundamental role in shaping migration decisions, particularly in determining whether migration is undertaken individually or as a household unit. Results showed that most household heads were married across all LGAs, with Kano Municipal reporting the highest proportion (87.2 percent) as shown in Table C. 65 percent of the household heads at Fagge were married while Gwagwalada (82.2 percent), and Kwali (80 percent) experienced similar marital status among household heads. However, a slight difference was noticed in Warri South-West which had the highest proportion of single household heads across the LGAs (22.8 percent) while 62.8 percent of the household heads were married. Meanwhile, Brass had the highest number of separated and divorced household heads across the LGAs (at 12.2 percent and 3.9 percent respectively), 58.3 percent of the household heads were married.

4.1.2.4 Educational attainment of household heads

Across the LGAs, there was a wide variation in educational levels underscores the persistent challenges of educational inequality in Nigeria, with Warri South-West LGA having the highest percentage of household heads with tertiary education (67.2 percent) and the lowest number of household heads with no formal education (0.6 percent) (Table C). Meanwhile, Kwali recorded the highest proportion of household heads with no formal education (26.6 percent). Brass had the lowest proportion of household heads with tertiary education (5.5 percent) while boasting the highest proportion of household heads with primary education (37.8 percent) and second highest for senior secondary education (40 percent) across the LGAs.

There was a relatively low representation of household heads who obtained technical school and vocational levels of education with no representation at Brass LGA (0 percent each). On average, the most represented categories of education attainment were household heads who attended senior secondary schools and tertiary institutions.

4.1.2.5 Household size and number of dependants on household heads

Household size and the number of dependants are critical factors influencing migration, as larger households often face higher socioeconomic pressures, influencing the decision to migrate. Table C shows that most households fall within the 2-5 household size category. For example, in Fagge LGA, 66.7 percent of households had 2-5 members, while the same could be said of Warri South-West (74.4 percent), Gwagwalada (55 percent), Kwali (50.6 percent) and Brass (66.6 percent). Likewise, the 6-9 household size category was the second most prominent across the LGAs. Kano Municipal had the most of its household sizes between 6 and 9 (at 22.2 percent). There were minor representations of households that had sizes of 14 and above.

Similarly, most household heads had dependants within the 2-5 household size category across the LGAs such as Kano Municipal (31.1 percent), Fagge (49.4 percent), Gwagwalada (43.9 percent), Kwali (68.3 percent), Warri South-West (71.1 percent), and Brass (72.8 percent). Conversely, there were minor representations of households with sizes of 10 and above with Kano Municipal indicating some notable proportion of dependants between 10 and 13 (24.4 percent).

4.1.2.6 Employment status and occupation of household heads

Employment status affects migration decisions. Most of the household heads across the LGAs were employed with percentages ranging from the lowest (41.1 percent in Gwagwalada) to the highest (83.3 percent in Warri South West) (Table C). This high level of employment confirms that most household heads were economically active. However, the presence of unemployed household heads, particularly in Gwagwalada (43.9 percent), highlights the challenges of job insecurity and underemployment in certain regions. Additionally, the relatively high percentage of students/apprentices in some LGAs, such as Gwagwalada LGA (43.9 percent), Fagge (23.3 percent) and Brass (23.3 percent) indicate the existence of economic challenges at these locations. Meanwhile, very few of the household heads were retirees as reflected in Kano Municipal (0.6 percent).

The occupational distribution of household heads further provides insights into the economic activities that sustain their households. Service provision was the major source of employment in most of the LGAs, being dominant in Kwali (89.5 percent) and Warri SouthWest (30.5 percent). Trading was the predominant occupation in Kano Municipal (54.2 percent), Brass (39.4 percent), and Gwagwalada (34.8 percent). Fishing was dominant in the coastal community of Brass (56.9%) while Kano Municipal was notable farming. The absence of occupation in the manufacturing sector in most LGAs suggests a reliance on subsistence economies.

4.1.2.7 Income levels of household heads

Income levels are a key determinant of socio-economic status and migration potential. There was a wide variation in income status across the LGAs (Table C). In Gwagwalada LGA, 61.1 percent of respondents reported an income of less than N26,000, while in Warri South West LGA, 61.3 percent reported an income above N520,001. Other notable LGAs with household heads earning more than N520,001 include Kwali (38.6 percent) and Brass (37 percent). Aside from Gwagwalada, Fagge was the other location where household heads had a high proportion of an income of less than N26,000 (34.5). No household head at Kano Municipal had an income above N520,001.

4.1.3 Migration patterns at the origin and destination hotspots of Nigeria

4.1.3.1 Analysis of migration intentions in various communities

The intention to migrate varies across different communities, as presented in Figure 4.29. Zango exhibited the highest prevalence of migration intention, with 66.7 percent of respondents affirming the desire to migrate. In contrast, respondents from Wako had the lowest intention to migrate, with only 6.7 percent expressing such aspirations. Sabon Gari East, Twon (both 15.6 percent), Tudun Nufawa (16.7 percent), and Central (20 percent) reported relatively low levels of migration intention. The proportion of respondents expressing migration intentions was higher in Zuba and Tungamaje, at 60 percent and 46.7 percent, respectively. Among the coastal communities, Ogidigben, Ugborodo, Twon, and Odioma displayed varying levels of migration intention, ranging from 15.6 percent to 33.3 percent. The proportion of respondents who had no intention to migrate was relatively high in several communities, including Tudun Nufawa, Sabon Gari East, Central, Ugborodo, Twon, and Odioma.

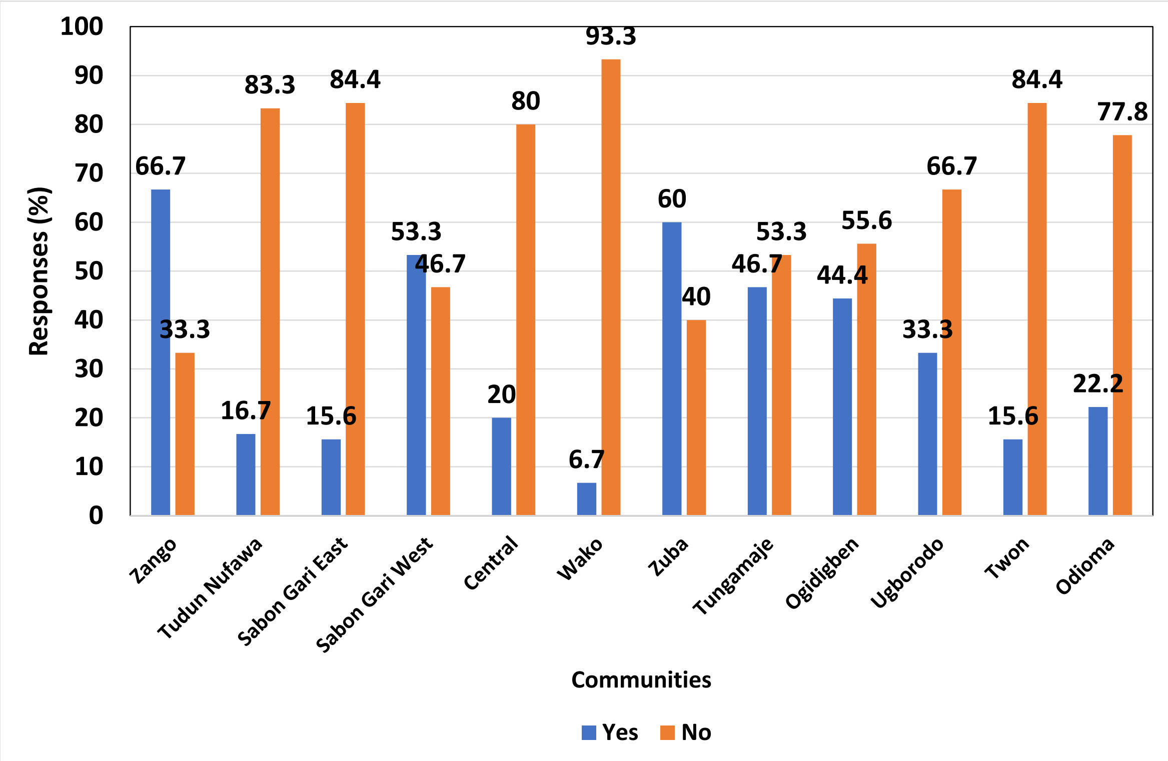


Figure 4.29: Migration Intentions in Various Communities

In many of the communities, the households were not willing to migrate. A participant at Zango wished to migrate but expressed limitations in the means to achieve his intention:

"We wish to leave this place and relocate our business due to the flooding situation here, but we do not have anywhere else to go".

Meanwhile, a businessman at Tudun Nufawa was emphatic about not migrating:

"This is my base, and my family is here, and I work here. I grew up here, and I have no other place to go to. We do not migrate from this place due to the flooding. We try to manage the situation because we know that this situation is seen as temporary and the season will be over again".

The same intention was echoed by a male FGD participant at Central:

"No, we do not intend to migrate".

A female worker at Twon had a contrary opinion:

"*I wish to leave in case the effects of the sea level rise become more severe in the future"*

4.1.3.2 Exploring first-time migration in destination communities

Figure 4.30 illustrates the proportion of first-time migrants among migrants in the destination communities. The highest proportion of first-time migrants was observed in Central and Wako, with 100 percent of the respective populations exhibiting this characteristic. Results showed that 80 percent of respondents in Zango were first-time migrants. Tudun Nufawa and Sabon Gari East also exhibited relatively high levels of first-time migration, with 63.3 percent and 15.6 percent, respectively. In contrast, Sabon Gari West and Zuba displayed more balanced proportions, with 53.3 percent and 60 percent of respondents signifying first-time migration, respectively. Conversely, 84.4 percent of respondents from Sabon Gari East had previous migration experience, suggesting a higher prevalence of internal mobility.

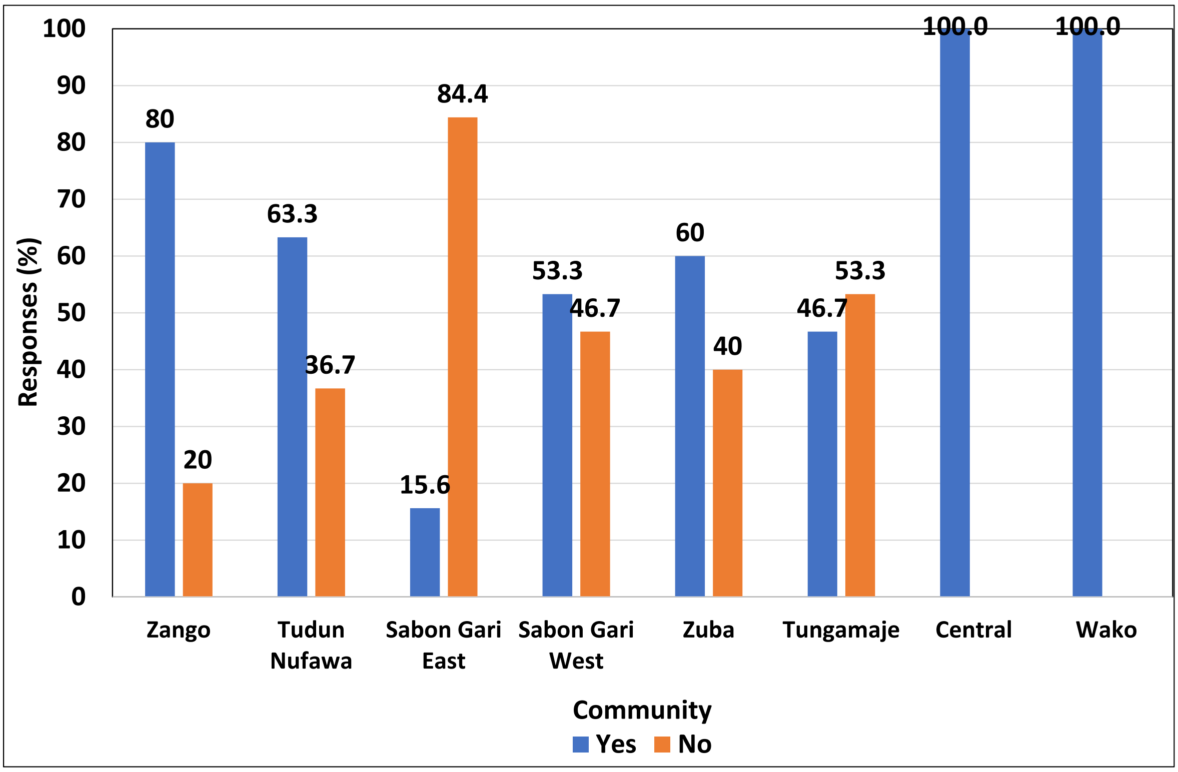


Figure 4.30: Proportion of First-Time Migrants at the Destination Locations

4.1.3.3 Analysis of the origin of migrants

At Kano Municipal, most migrants were from the neighbouring states of Jigawa (21 percent) and Katsina (19 percent) (Figures 4.31 and 4.32). Migrants also moved in from Oyo and Sokoto States, among others. Most migrants at Fagge were from Adamawa (9 percent), Katsina (8.5 percent), and Lagos States (8.5 percent) (Figures 4.33 and 4.34). Other migrants were from states such as Jigawa, Plateau, Imo and Kaduna. Geographically, it was observed that aside migrants from the northwest axis of the country, most of the migrants in Fagge originated from the southeastern and south-southern axes of Nigeria. As illustrated in Figures 4.35 and 4.36, the migrants in Kwali communities were predominantly from originated from Niger, Benue, Kano, Katsina, Kaduna, Nasarawa and Kogi States. At Gwagwalada, the majority of migrants were from Niger, Edo, Kaduna, and Kogi States (Figures 4.37 and 4.38).

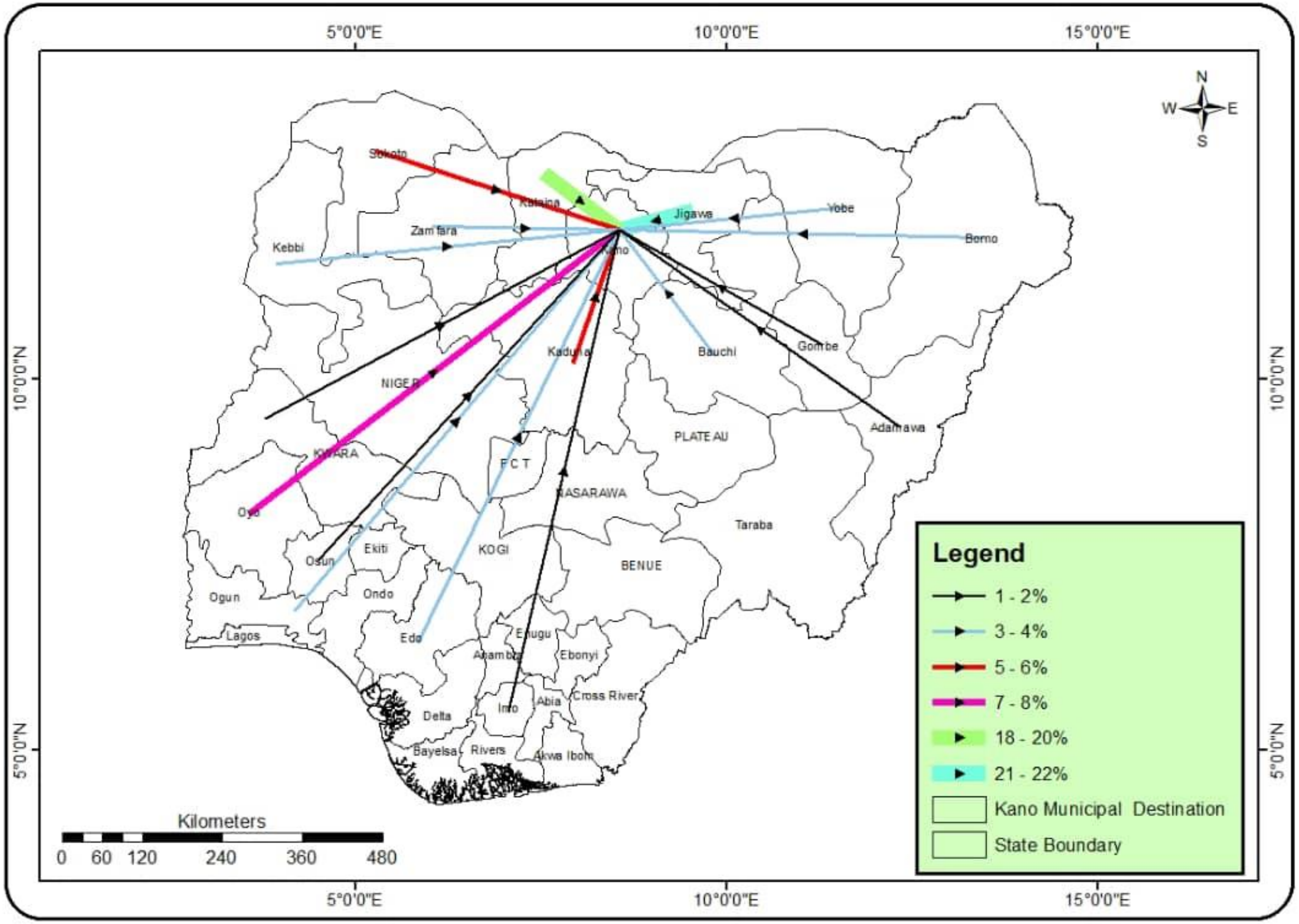


Figure 4.31: Flow Map of migrants to Kano Municipal

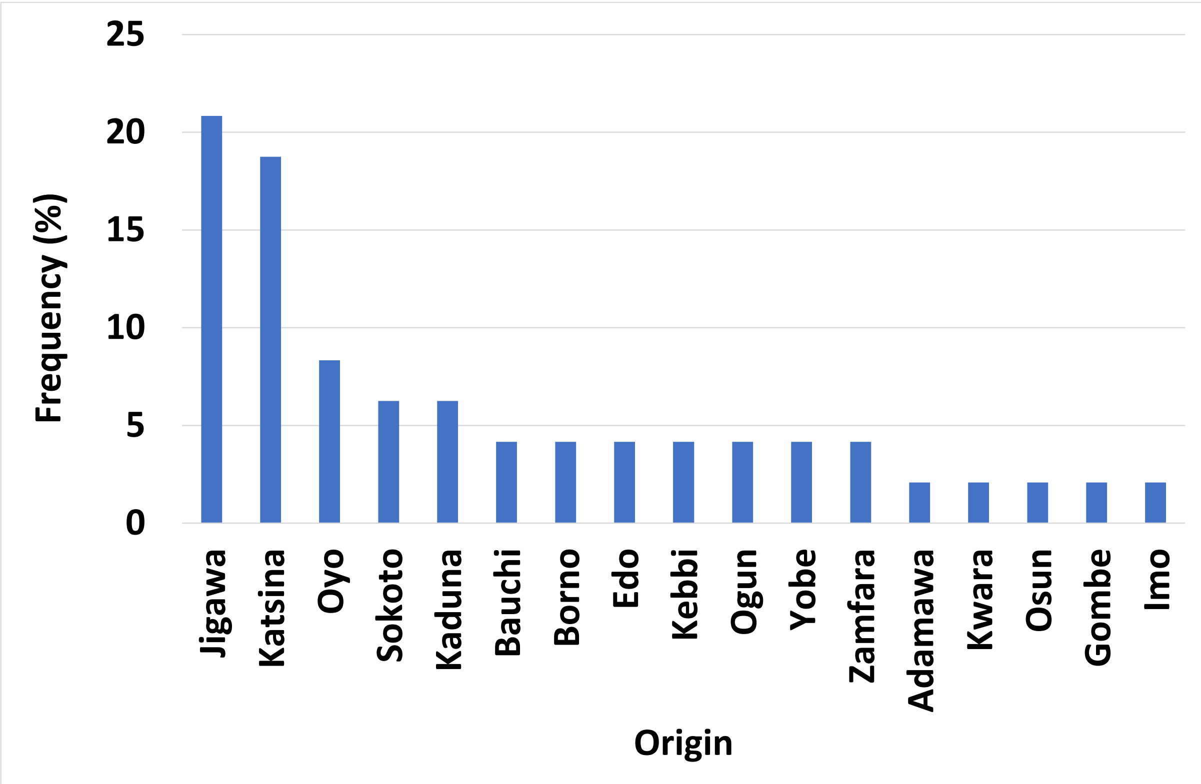


Figure 4.32: Percentage Frequency of Migrants to Kano Municipal

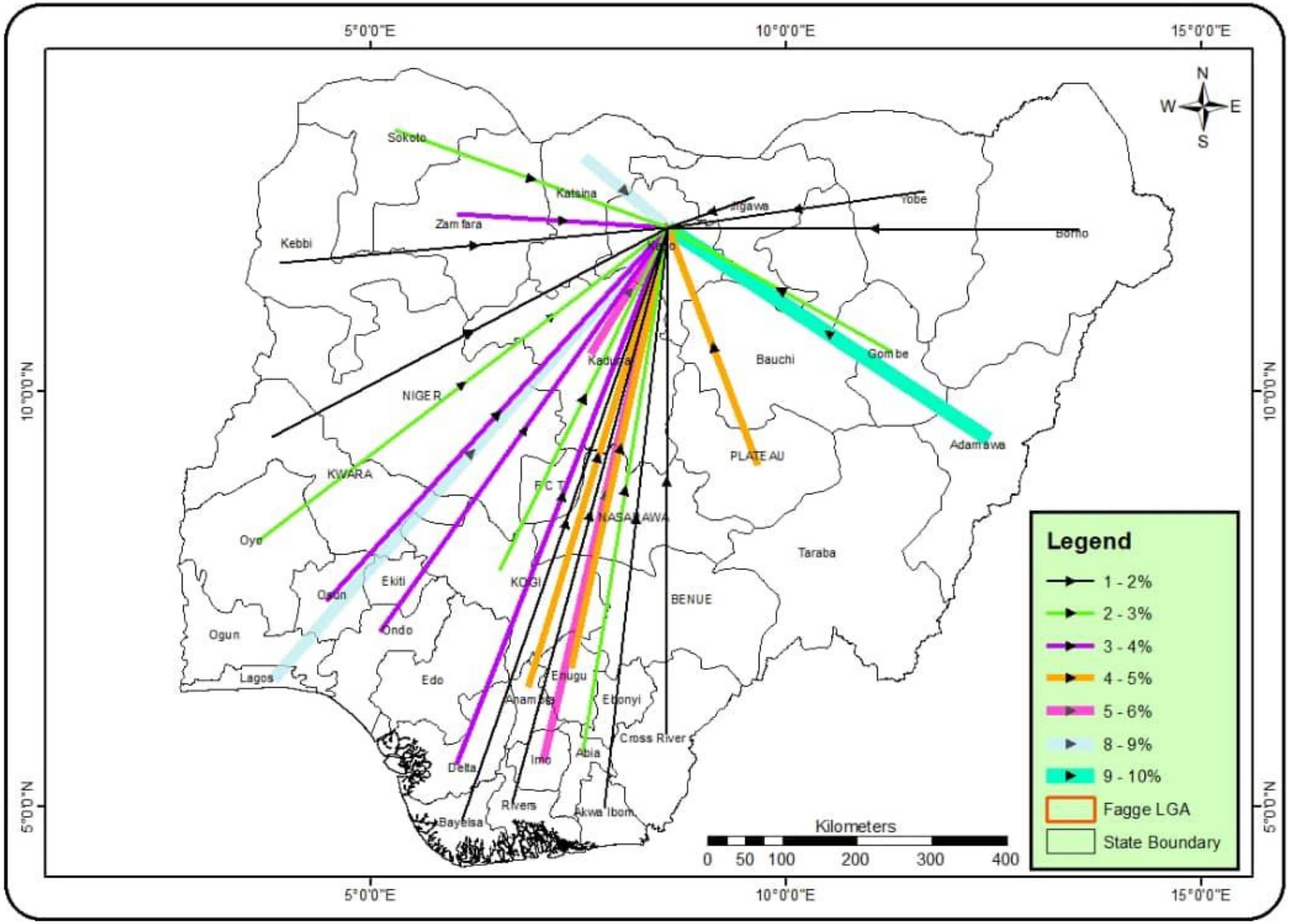


Figure 4.33: Flow Map of Migrants to Fagge

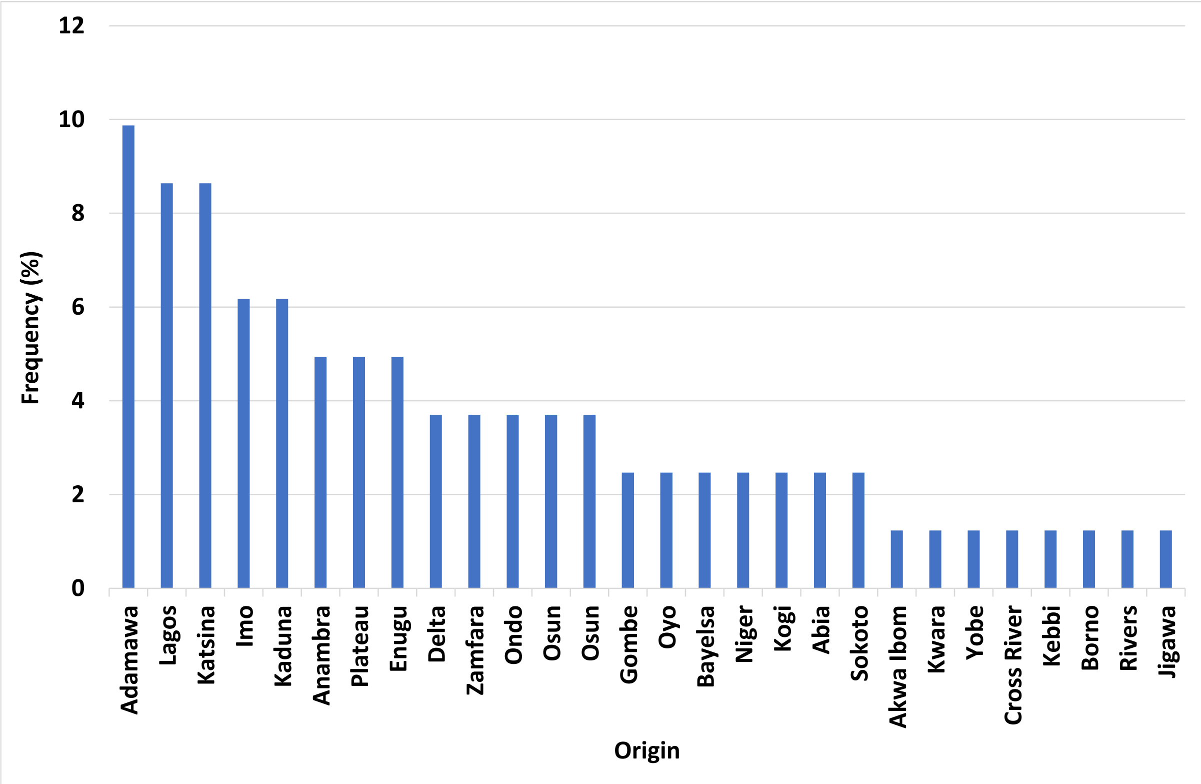


Figure 4.34: Percentage Frequency of Migrants to Fagge

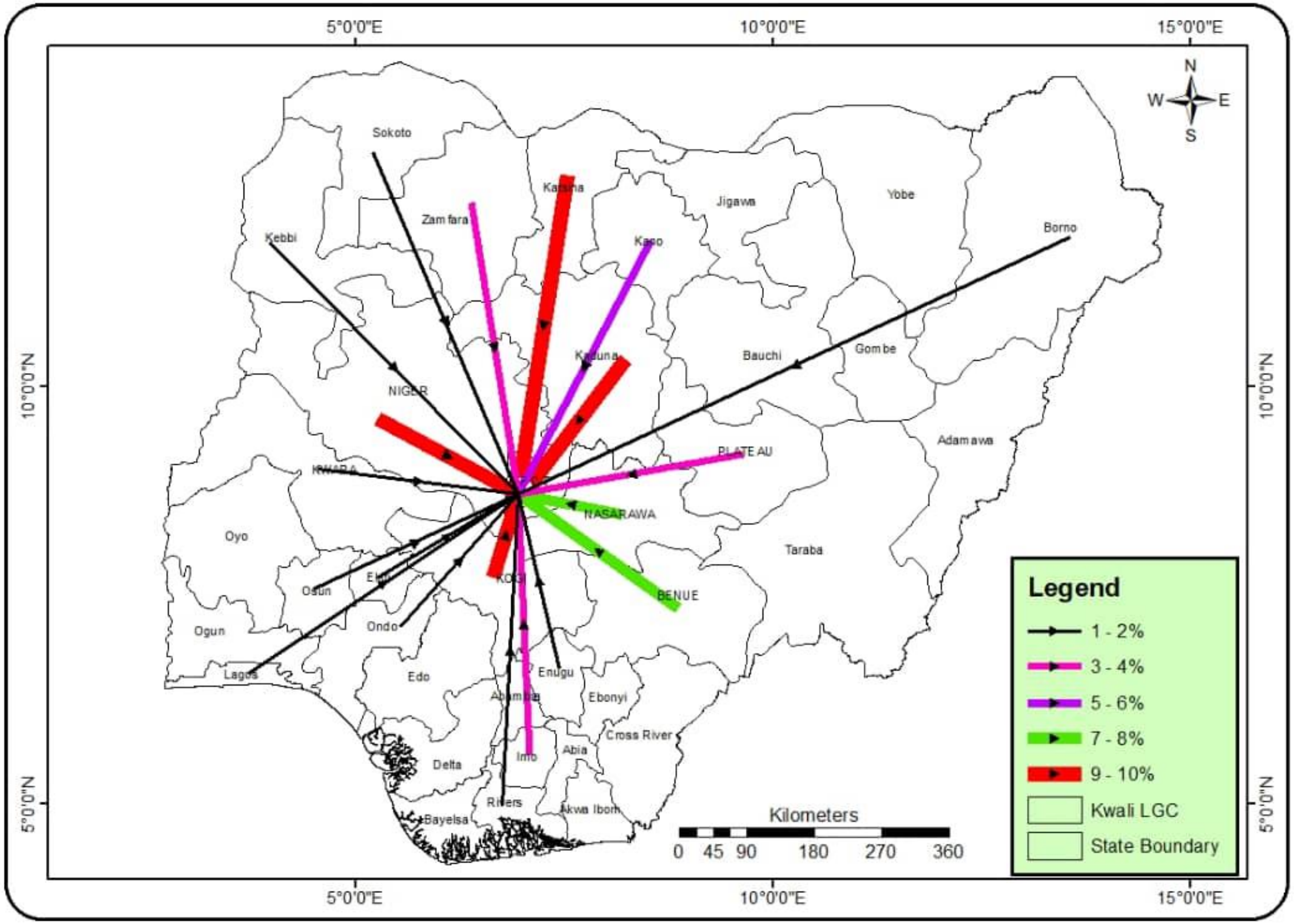


Figure 4.35: Flow Map of Migrants to Kwali

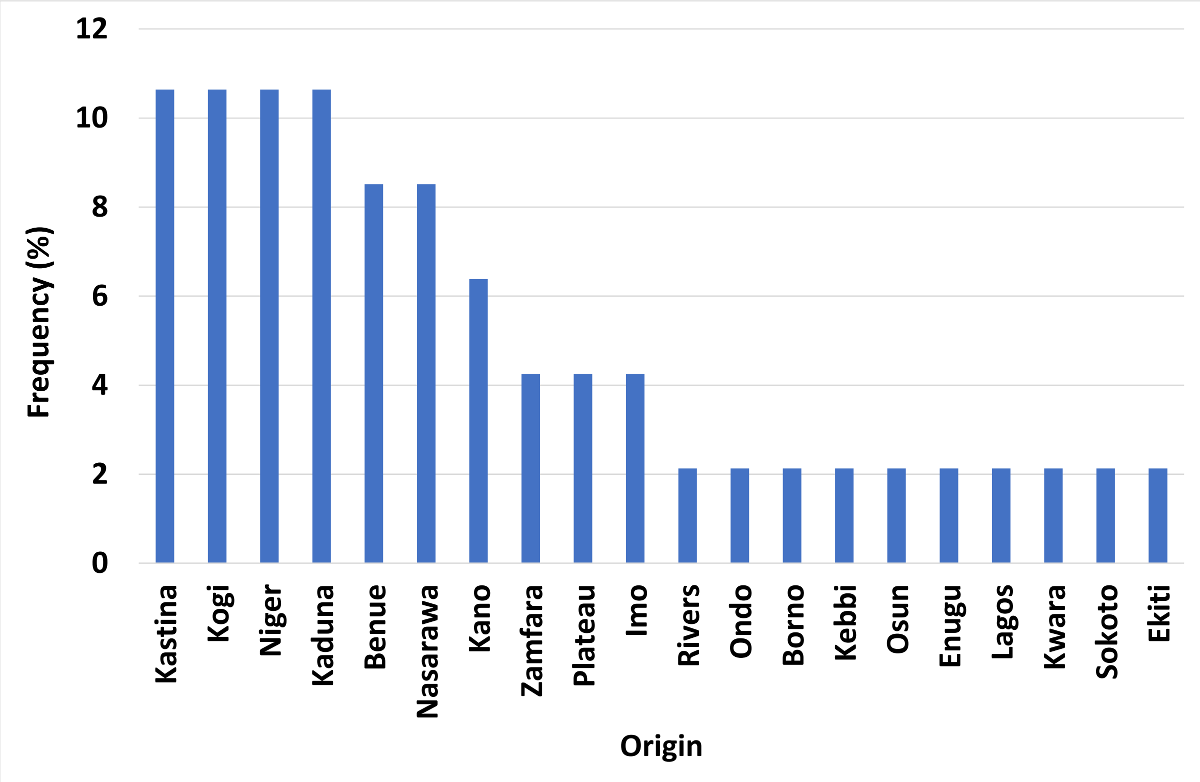


Figure 4.36: Percentage Frequency of Migrants to Kwali

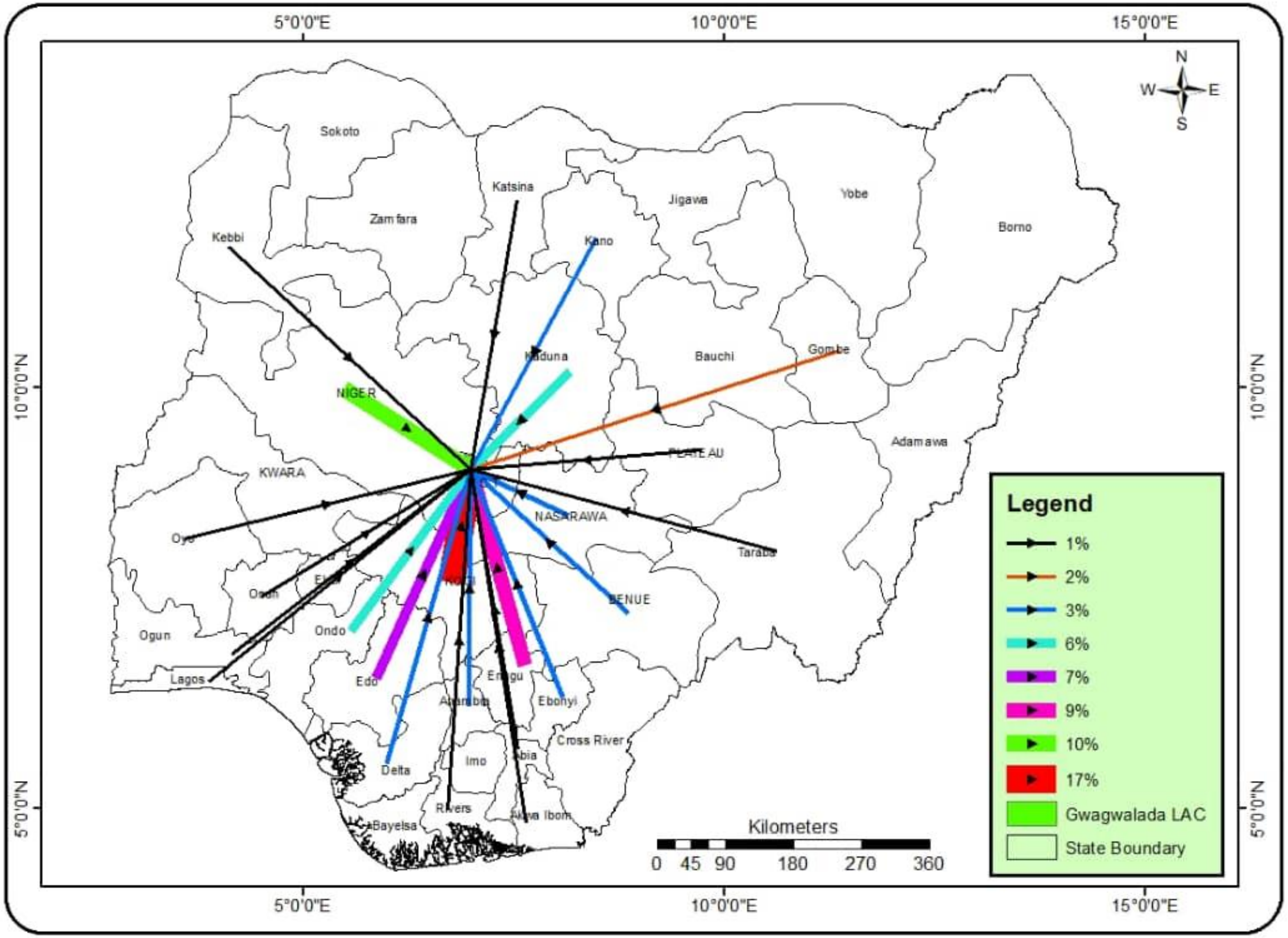


Figure 4.37: Flow Map of Migrants to Gwagwalada

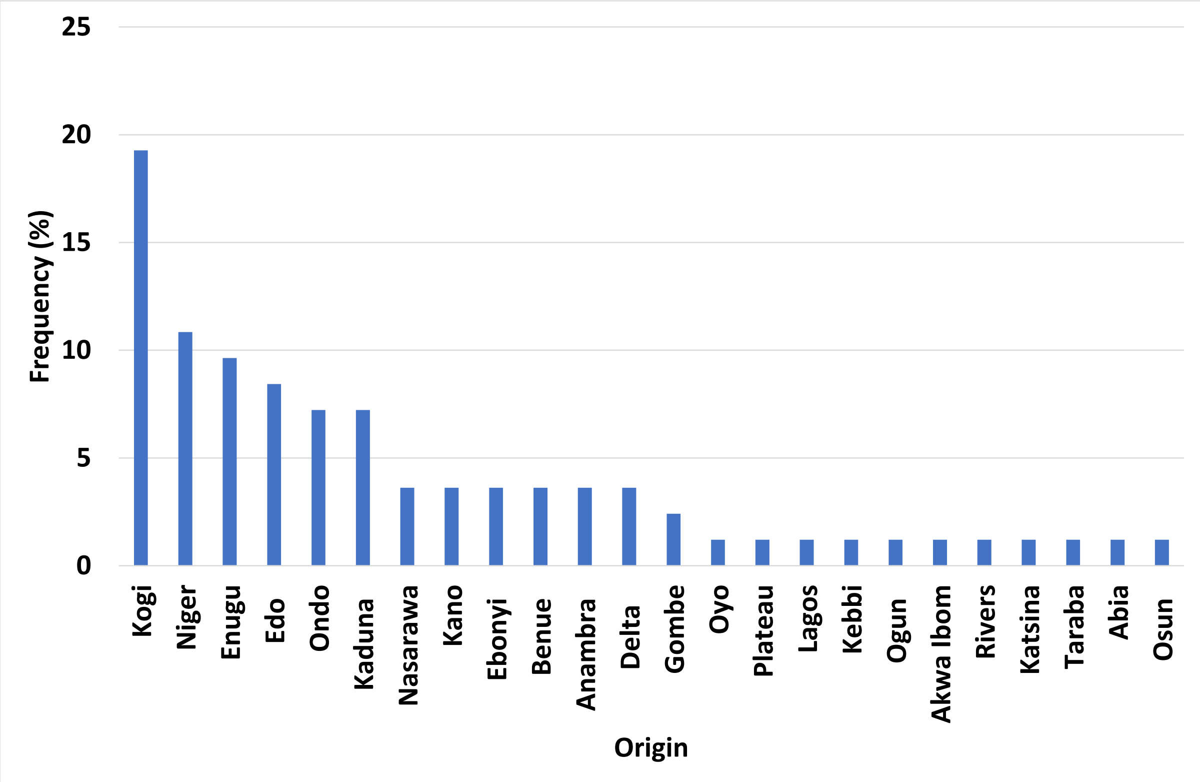


Figure 4.38: Percentage Frequency of Migrants to Gwagwalada

4.1.3.4 Analysis of goals attainment and benefits of migration

Migration is a multifaceted phenomenon with various impacts on individuals and communities. In the analysis of the perception survey to ascertain whether respondents had achieved their migration goals (Figure 4.39), Tungamaje had 37.8 percent of respondents affirmed the achievement of their migration goals, as 35.6 percent felt that they were likely to achieve them.

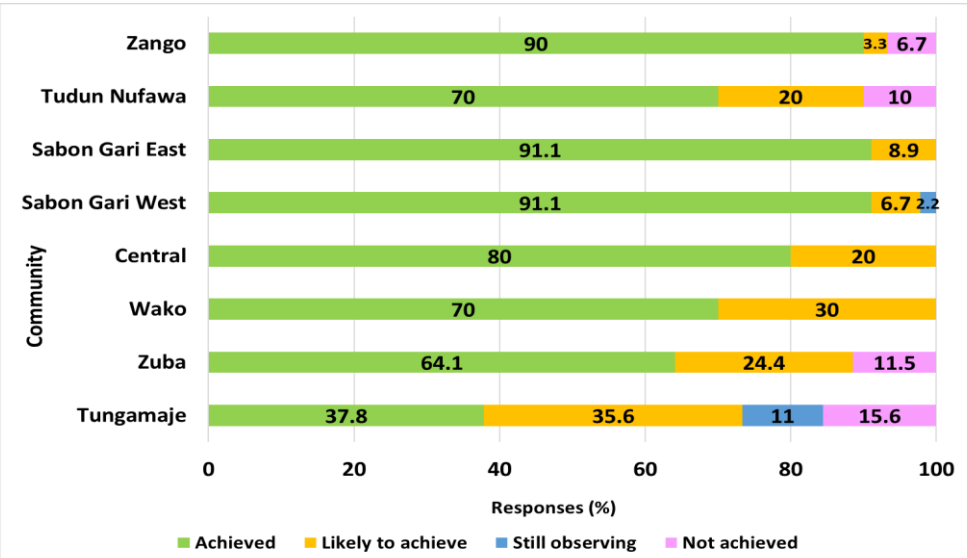


Figure 4.39: Achievement of Migration Goals

Zuba exhibited a higher proportion of achieved goals (64.1 percent) and a lower proportion of those likely to achieve them (24.4 percent). Wako and Central also exhibited relatively high levels of goal attainment, with 70.0 percent and 80.0 percent, respectively. In contrast, Sabon Gari West and Sabon Gari East exhibited exceptionally high levels of goal achievement, with 91.1 percent each. Tudun Nufawa and Zango also reported high levels of goal attainment, with 70.0 percent and 90.0 percent, respectively. While most respondents affirmed that they have achieved their goals, a small proportion of respondents across various communities notified that they were still observing the outcomes of their migration, while others reported not achieving their goals (Figure 4.40).

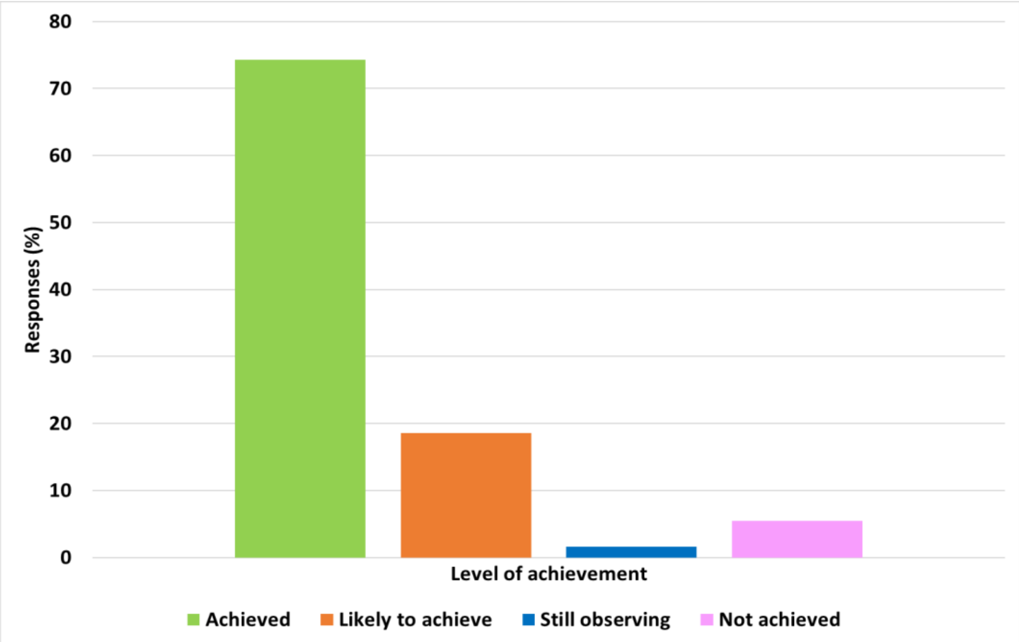


Figure 4.40: Ranking of Achievement of Migration Goals

Figure 4.41 illustrates the level of agreement with migration being beneficial, demonstrating the varying degrees of agreement, disagreement, and neutrality across the communities. In Wako, 36.7 percent of respondents strongly agreed that migration had been beneficial, while 43.3 percent agreed. In Central, 60.0 percent of respondents showed a high level of perceived benefit by strongly agreeing with the statement. Conversely, in Tungamaje, only 2.2 percent of respondents strongly agreed with the statement, with 64.4 percent agreeing. Zuba exhibited the highest level of agreement, with 82.2 percent of respondents having a strong agreement and 11.1 percent disagreeing. The perceptions of Sabon Gari West and East exhibited a notable degree of ambivalence, with a significant proportion of respondents expressing both agreement and disagreement. The levels of agreement observed in Tudun Nufawa and Zango were moderate, with 60.0 percent and 20.0 percent of respondents, respectively, showing a strong level of agreement. In all, most of the respondents strongly agreed that migration has been beneficial to them, followed by a considerable proportion of those who strongly agreed to the migration benefits (Figure 4.42).

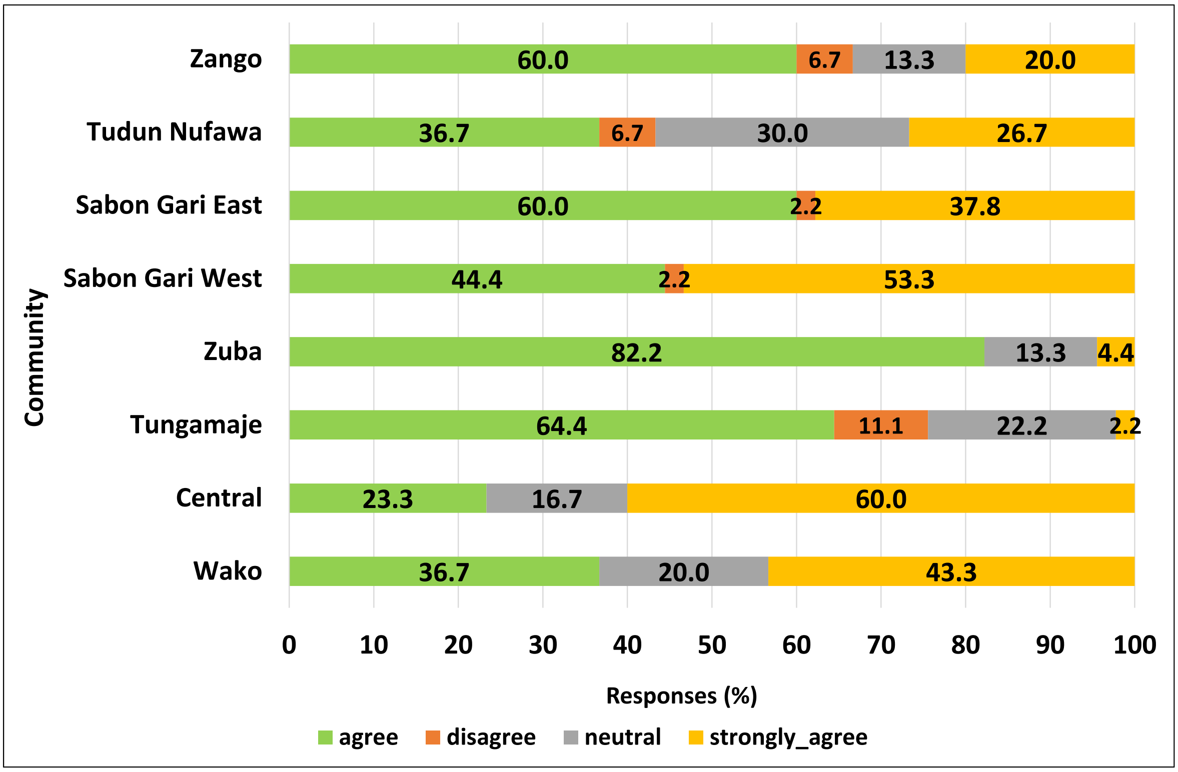


Figure 4.41: Level of Agreement with the Perception of Migration being beneficial

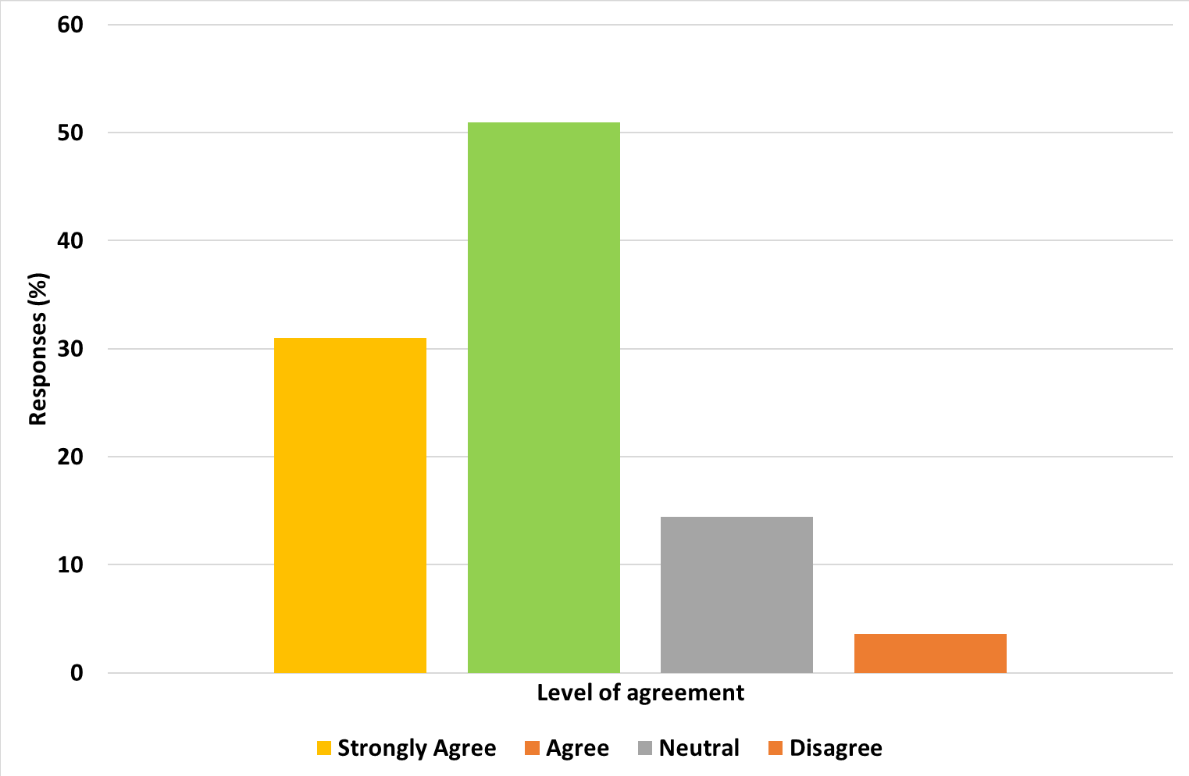


Figure 4.42: Ranking of Agreement Level on Migration being beneficial

4.1.3.5 Analysis of personal benefits of migration

Figure 4.43 reveals that respondents from Wako perceived a range of benefits, with improved security (40.0 percent) and more opportunities (32.5 percent) being the most prevalent. This is comparable to the experiences of respondents at Tungamaje, who reported improved security (42.6 percent) and more opportunities (19.1 percent) as the primary benefits. The respondents from Central exhibited a high perception of improved security (46.2 percent) and improved finances (25.6 percent). At Zuba, the most frequently reported benefit was the creation of new opportunities (44.8 percent), followed by an improvement in financial circumstances (13.8 percent). Sabon Gari West and Sabon Gari East reported more benefits, with opportunities and skills development being more prominent. At Tudun Nufawa, respondents identified more opportunities (31.1 percent) and improved finances (26.7 percent) as the most significant benefits. In contrast, skills development (34.1 percent) was the most frequently cited benefit, followed by more opportunities (15.9 percent) at Zango.

In all, it can be deduced that most migrants at the destination communities relocated due to available opportunities. Aside the search for more opportunities, others migrated to ensure improved security. Meanwhile, very few migrants relocated to have a better environment. This buttresses the minimal influence of the environment on migration decisions, as compared to socioeconomic reasons.

The Kruskal-Wallis test distribution showed a statistically significant difference in the perception of benefits derived by individuals due to migration (H = 110.867, $p < 0.05$) (Table S1). The post hoc test identified the significant pairwise difference between Zango and Tudun Nufawa (H = -171.989, $p < 0.05$), Central (H = -186.833, $p < 0.05$), Sabon Gari West (H = -198.524, $p < 0.05$), Zuba (H = -204.539, $p < 0.05$), Wako (H = -217.038, $p < 0.05$), Sabon Gari East (H = -227.429, $p < 0.05$), and Tungamaje (H = -249.074, $p < 0.05$) (Table D3).

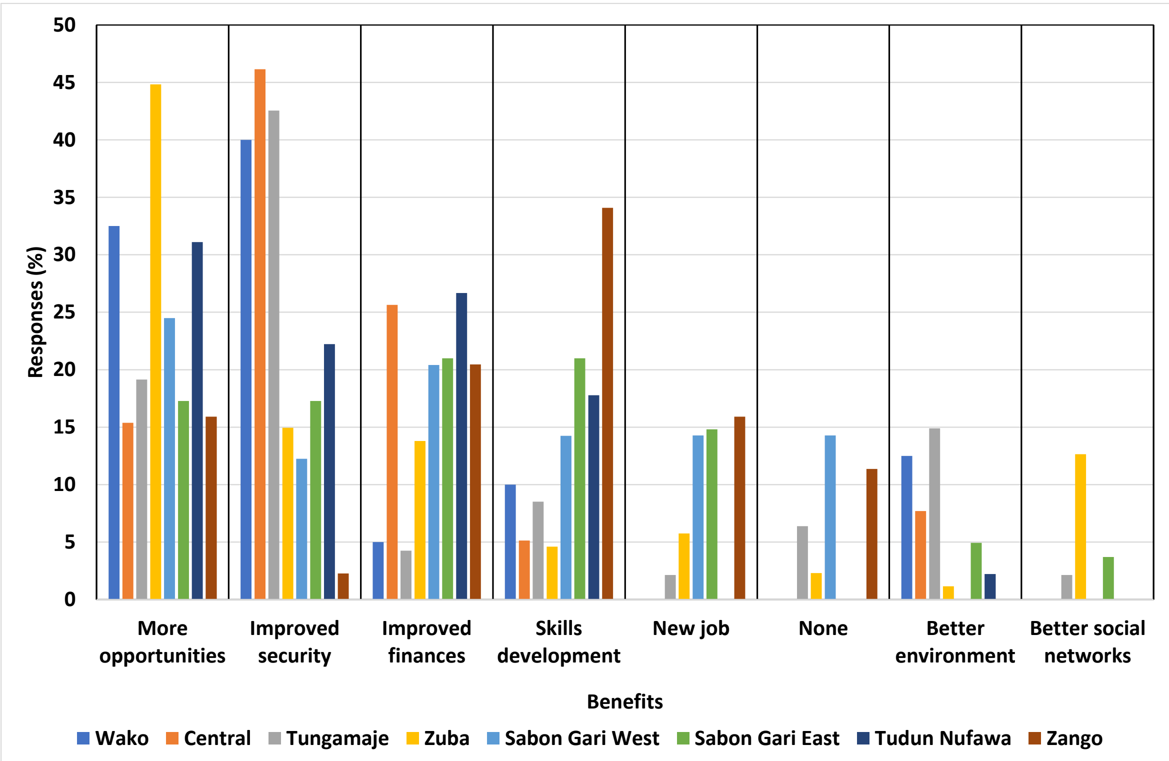


Figure 4.43: Benefits of Migration to the Migrants

4.1.3.6 Opinion of respondents on knowing anyone else who migrated from the community and the drivers of their migration

Figure 4.44 indicates the respondents' knowledge of migrants who left their respective communities. The respondents from Tudun Nufawa, Tungamaje, Ogidigben, and Ugborodo reported a relatively moderate level of awareness regarding households that had migrated from their communities, with proportions ranging from 26.7 to 42.2 percent. Conversely, the respondents from Twon, Odioma, and Central demonstrated a markedly low level of awareness, with proportions ranging from 4.4 to 10 percent. The communities of Zango and Wako reported no knowledge of migrants from their communities. On average, there was very little knowledge of households migrating from communities of origins

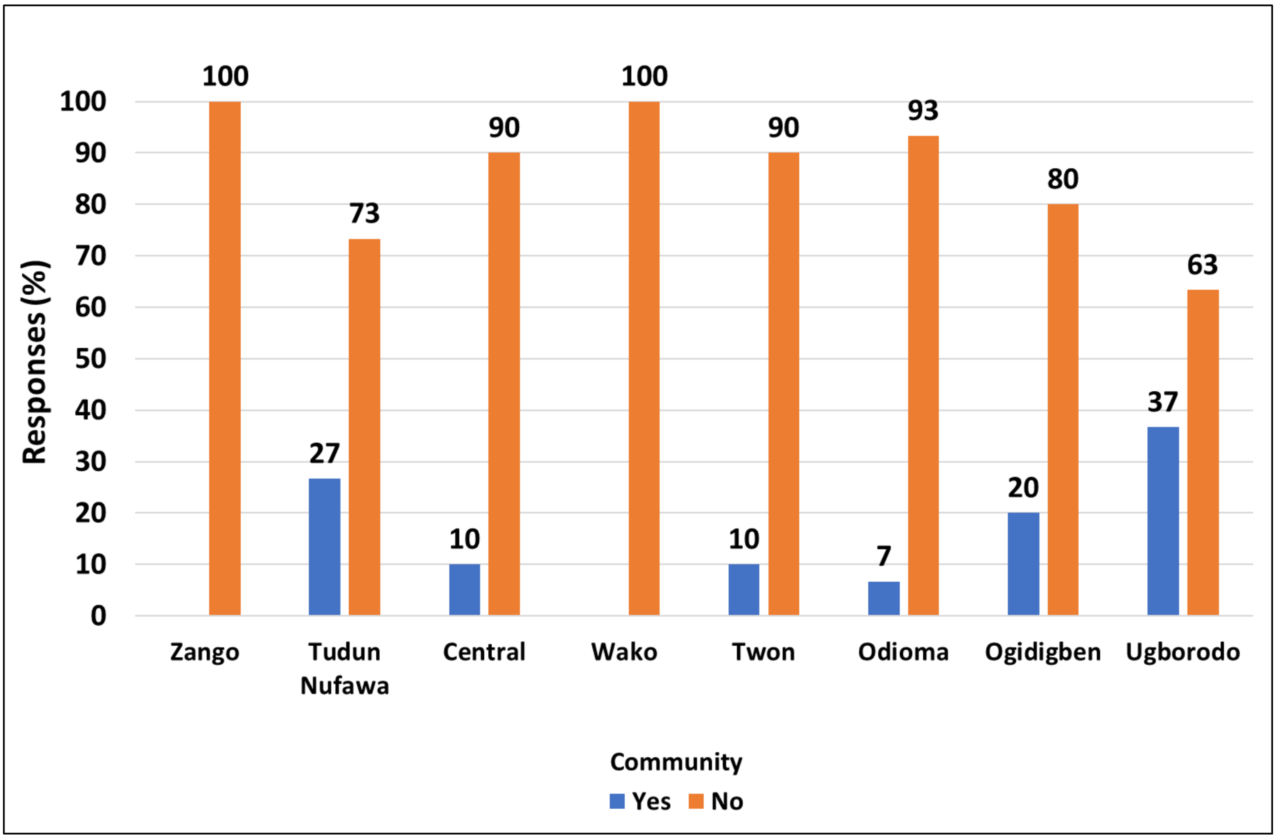


Figure 4.44: Opinion of Respondents on knowing anyone else who migrated from the Community

4.1.3.7 Analysis of the destination locations of those who migrated from the community

Figure 4.45-4.47 show the destination locations of the migrants who departed from locations of origin. Kano Municipal had the most migrants relocating to Jigawa State (60 percent) (Figure 4.45), indicating a consistent cross-migration between Kano and Jigawa State. From Warri SouthWest of Delta State, community members moved majorly to Lagos, Abuja and Rivers State (Figure 4.46), while a few others migrated to the neighbouring Bayelsa State. Community members from Brass (Bayelsa State) migrated majorly to Rivers, Cross River and Imo States (Figure 4.47).

4.1.4 Socioeconomic, climatic and environmental drivers of migration in Nigeria

4.1.4.1 Analysis of migration reasons from communities of origin

According to Table 4.11, the primary reason for migration from Tungamaje was the search for business opportunities (30 percent), followed by inadequate farmlands (40 percent). Other reasons for migration out of the community included education, adventure, and the unavailability of land (all at 10 percent). All the migrants from Zuba (100 percent) cited job opportunities as the primary reason for their relocation. At Central, migration was driven by the pursuit of business opportunities, educational advancement, and employment (all 33.3 percent). Similarly, Sabon Gari West had a multitude of reasons for out-migration, including business opportunities (30 percent), land degradation (20 percent), insecurity (10 percent), persistent drought (30 percent) and inadequate job opportunities (30 percent).

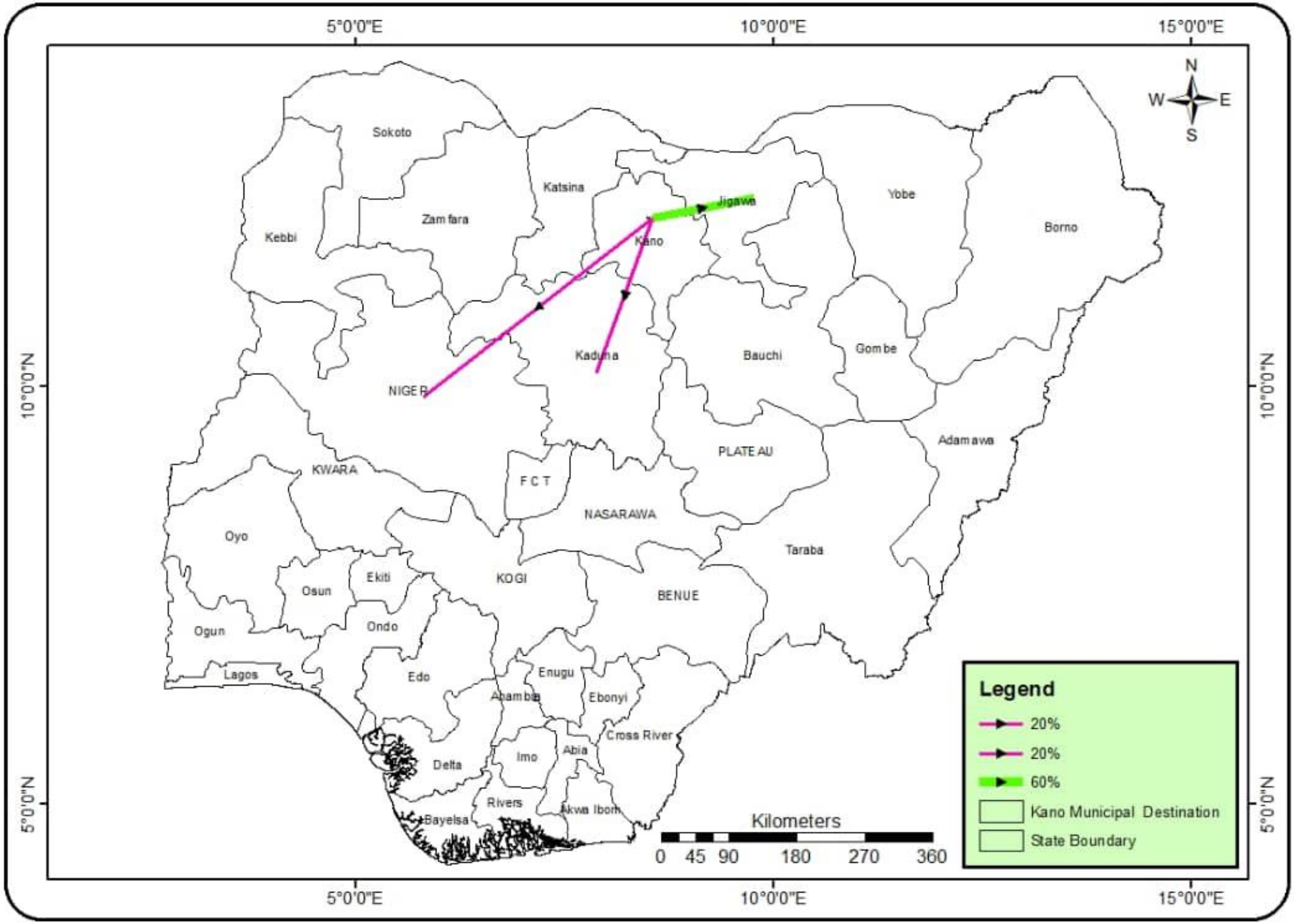


Figure 4.45: Flow Map of Migrants' Destinations away from Kano Municipal

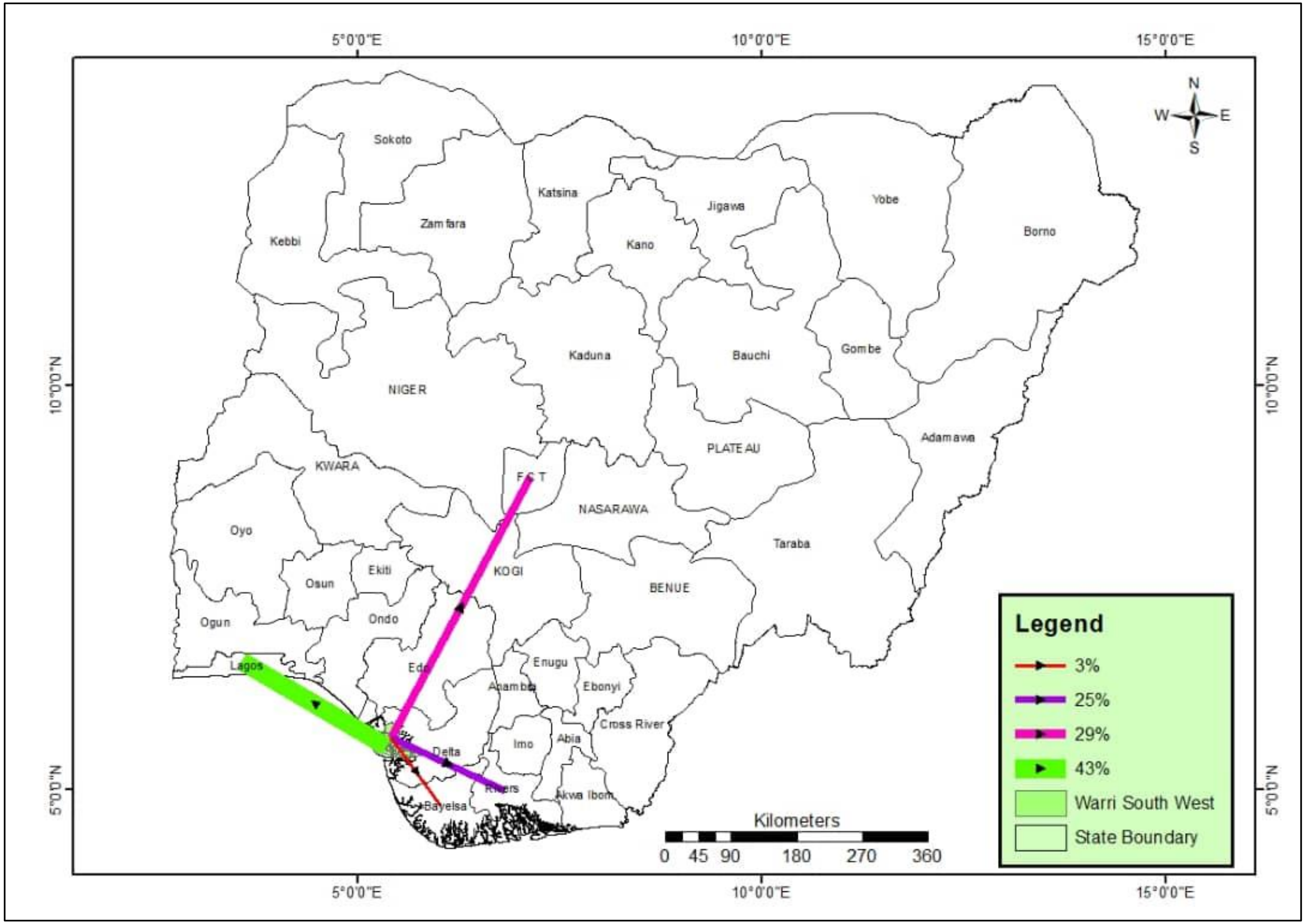


Figure 4.46: Flow Map of Migrants' Destinations away from Warri Southwest

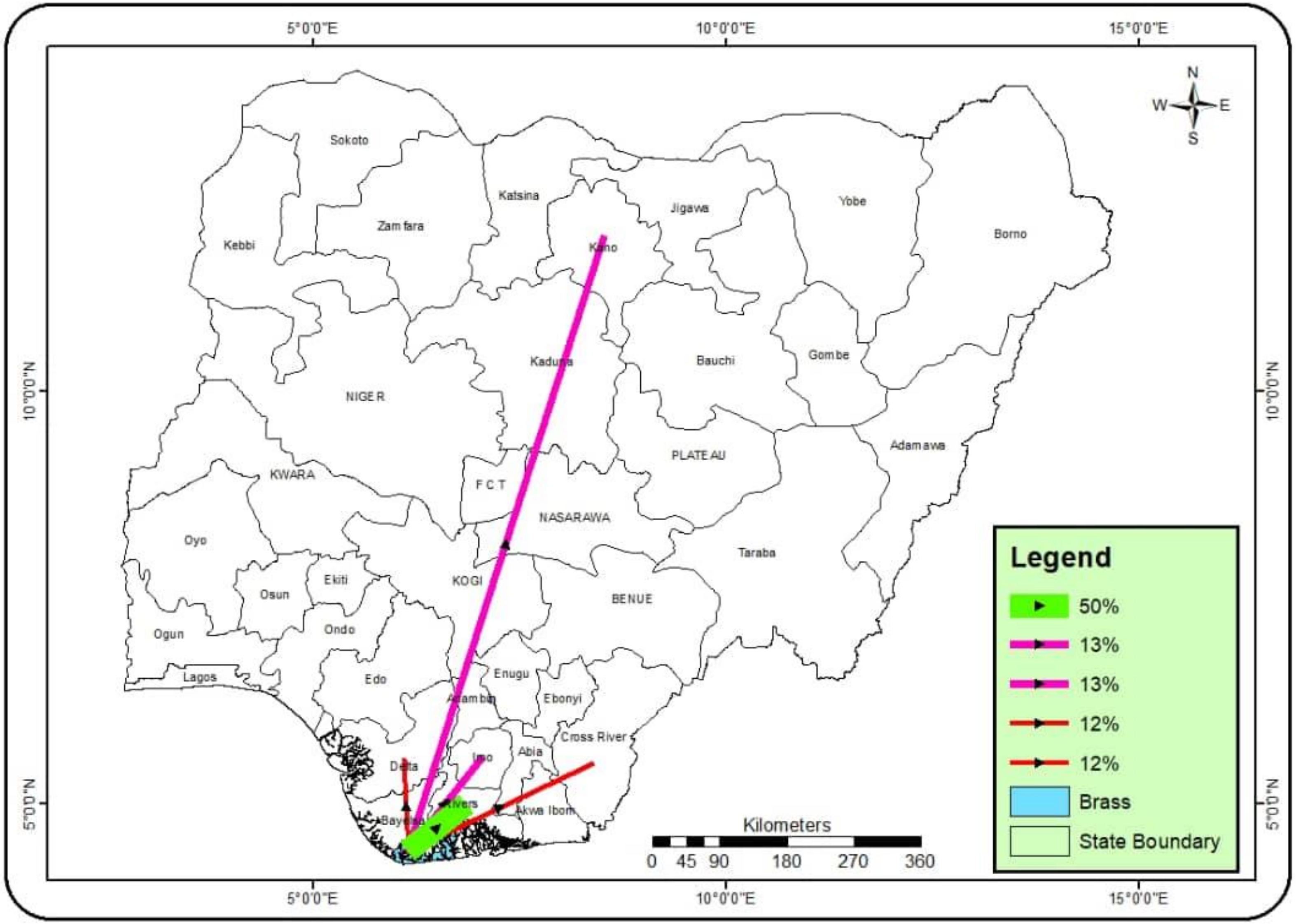


Figure 4.47: Flow Map of Migrants' Destination away from Brass

At Tudun Nufawa, migration was attributed to business opportunities and flooding (22.2 percent each), land degradation and socio-cultural ties (11.1 percent each), and inadequate farmlands (33.3 percent). The primary motivating factors for migration at Ugborodo were educational needs and the search for employment opportunities, with 32 percent of respondents citing each as their primary reason for leaving. Other causes included the search for business opportunities (16 percent), inadequate job opportunities, the unavailability of land (both 4 percent), and sea level rise (12 percent).

In contrast, the primary drivers of migration at Ogidigben were identified as the search for employment opportunities (60 percent), followed by educational needs (30 percent) and the lack of suitable agricultural land (10 percent). The search for business and job opportunities (both at 50 percent) were the primary causes of migration in Twon. Migrants that left Odioma were due to search for job opportunities (66.7 percent) and education needs (33.3 percent). The most frequently cited reason for migration was the search for job opportunities (Figure 4.48). This was followed by the desire for business opportunities, education needs and inadequate farmlands.

Table 4.11: Drivers of Migration of those who left the Community

	Odioma	Twon	Ogidigben	Ugborodo	Tudun Nufawa	Sabon Gari West	Central	Zuba	Tungamaje
Job opportunities	66.7	50	60	32	-	30	33.3	100	-
Business opportunities	-	50	-	16	22.2	30	33.3	-	30
Education	33.3	-	30	32	-	-	33.3	-	10
Inadequate farmlands	-	-	10	-	33.3	-	-	-	40
Land degradation	-	-	-	-	11.1	20	-	-	-
Flooding	-	-	-	-	22.2	-	-	-	-
Socio-cultural ties	-	-	-	4	11.1	-	-	-	-
Unavailability of land	-	-	-	4	-	-	-	-	10
Sea level rise	-	-	-	12	-	-	-	-	-
Insecurity	-	-	-	-	-	10	-	-	-
Persistent drought	-	-	-	-	-	10	-	-	-
Adventure	-	-	-	-	-	-	-	-	10

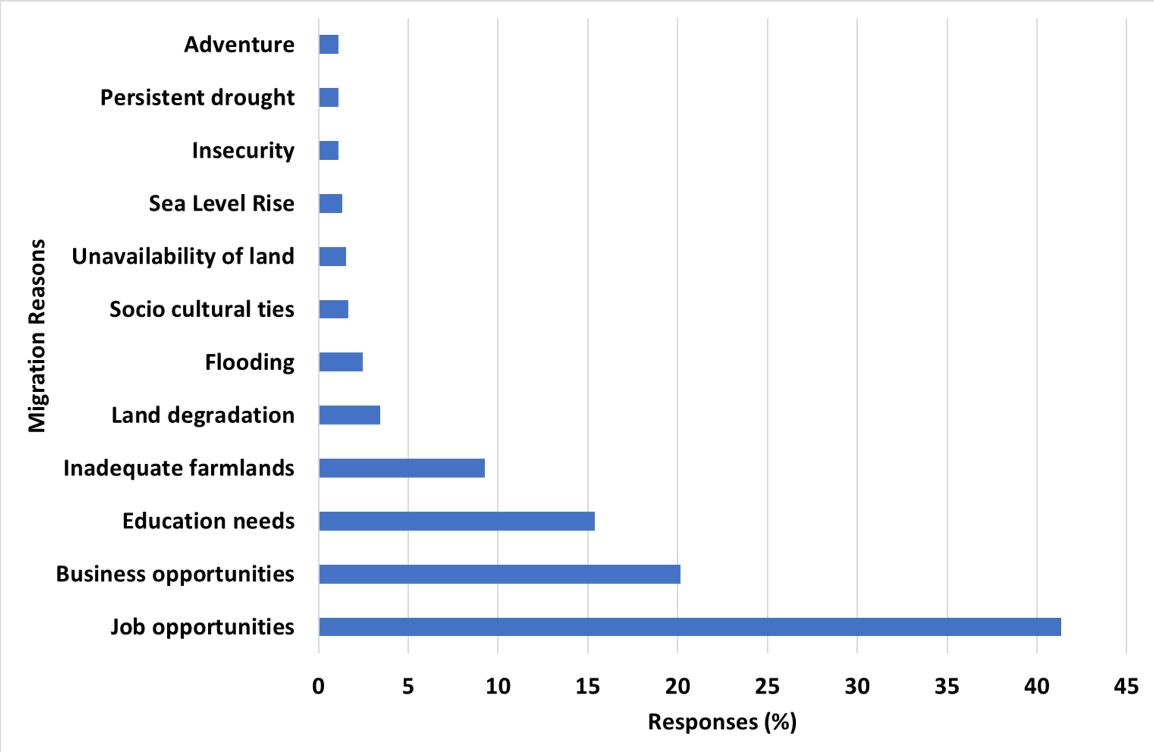


Figure 4.48: Ranking of Drivers of Migration for those who left the Community

4.1.4.2 Perception of the drivers of migration into destination communities

Migration is a complex phenomenon that is influenced by various factors. Figure 4.49 illustrates the drivers of migration as perceived by migrants from the study locations. Zuba reported the highest perception of job opportunities as a motivation for migration (50.0 percent), followed closely by Tungamaje (48.3 percent) and Sabon Gari East (38.1 percent). Additionally, business and trading opportunities were identified as significant migration motivations, particularly in Wako (58.1 percent) and Sabon Gari East (28.6 percent). Migrants from various destination communities highlighted the environment and climate as factors that influenced their decision to migrate. The proportion of environment/climate migrants was much less than that of business and job opportunities as migrants at Tudun Nufawa had most of the environment and climate migrants at 18 percent. Insecurity was identified as a migration motivation by migrants from Sabon Gari West (21.7 percent) and Zango (18.6 percent), suggesting the influence of security concerns on migration patterns. Education, land scarcity, and historical ties were perceived as less prominent migration motivations, though migrants from specific communities mentioned them. Job transfer was identified as a migration motivation by migrants from Central (45.2 percent), suggesting that employment-related factors play a significant role in migration decisions within this community.

Among the list of migration drivers, the influence of the environment and climate was ranked as the third topmost driver of migration in the communities under study. Most migrants identified job opportunities as the primary reason for their migration (34 percent), followed by business and trading opportunities (29 percent). The contribution of the environment and climate to the migration of migrants into the destination communities was 11 percent which was quite distant from the influences of job and business opportunities (Figure 4.50). The other drivers of migration into the destination communities were insecurity (8 percent), job transfer (8 percent), land scarcity (4 percent), and education (4 percent), among others.

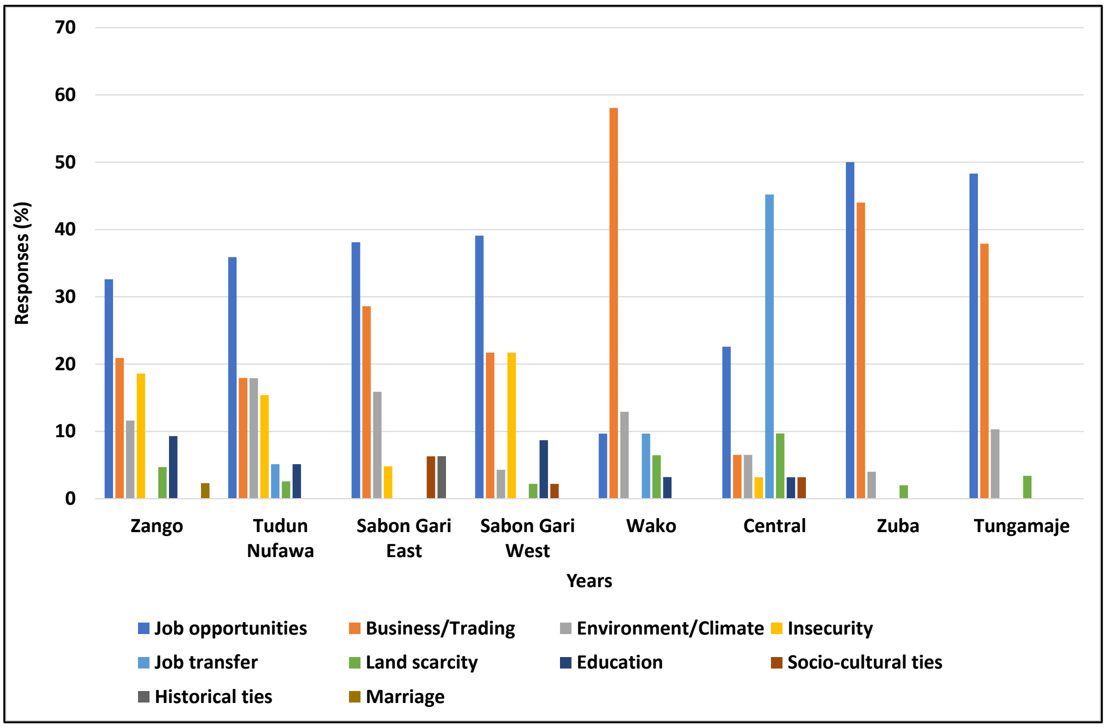


Figure 4.49: Perception of the Drivers of Migration by Migrants

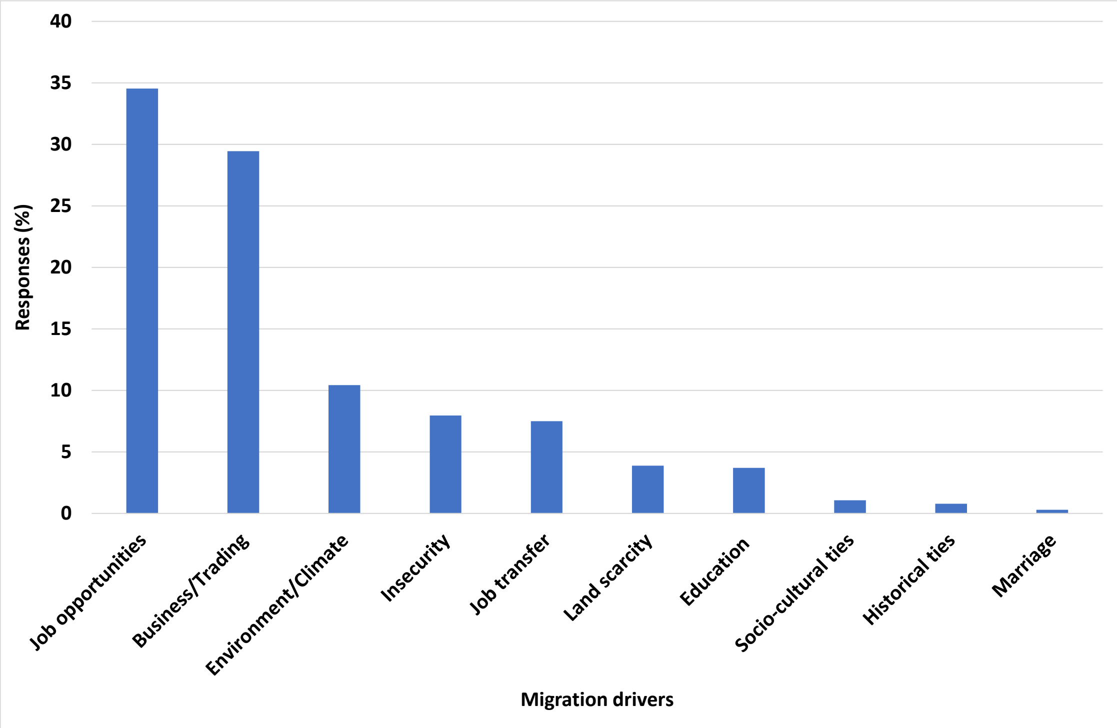


Figure 4.50: Ranking of Drivers of Migration

A breakdown of the emerging themes related to the various drivers of migration is shown in Table 4.12, where participants at the focus group discussions shared their perceptions of the major reasons why households migrate into or out of their communities. The major factors include job opportunities (which were linked to the COVID-19 pandemic in some communities), business opportunities, environmental factors, and security challenges. Some participants highlighted age factor (the aged), marital status and family sizes as constraints to migration. There was no statistically significant difference in the perception of drivers of migration across the communities ($H = 8.108$, $p = 0.423$) (Table D1). This establishes that most respondents migrated due to similar reasons (majorly for job and business opportunities).

Table 4.12: Emerging Themes of Various Drivers of Migration

Theme	Community	Extracts of Participants' Responses
Job opportunities	Twon, Odioma	People migrate out of this place to seek better job opportunities due to the devastating effects of the COVID-19 pandemic lockdown.
	Ugborodo	People migrate out for better means of livelihood other than farming and fishing activities.
	Ogidigben	Households are leaving the community to improve their economic situation.
Business opportunities	Sabon Gari East	People come around from various locations for business purposes.
	Sabon Gari West	This community is a commercial centre. People come in from various locations to have a means of livelihood.
Environment	Tudun Nufawa	Floods affect the economic situation, leading to the migration of households
	Ogidigben, Ugborodo	Coastal flooding affects the various infrastructure and facilities which impacts the socioeconomic activities, influencing households to migrate.
Peace of mind/Security	Wako	People migrate into this community due to the existing peace, serenity, and security
Other factors	Zango	Young people migrate to explore other aspects of life. They sell their properties and it is easier for them to migrate since they are yet to have families. The aged cannot do that. Family men find it more difficult to relocate their households due to the economic factors involved.
	Ogidigben	Those who do not migrate, stay behind due to their cultural attachment to the society.

4.1.4.3 Climate/environment-based push factors of migration

The analysis of the perceptions of migrants in the destination communities regarding the environmental and climatic factors that contributed to their migration specified persistent drought and inadequate rainfall as the prominent environment/climate-based push factors of migration (Figure 4.51). A total of 40 percent of respondents in Tudun Nufawa, 14.3 percent in Zango, 27.8 percent in Sabon Gari East, and 100 percent in Tungamaje identified inadequate rainfall as a significant push factor. Furthermore, persistent drought was perceived as a major push factor in several communities, particularly in Zango (71.4 percent), Sabon Gari East (44.4 percent), Central (75.0 percent), and Wako (28.6 percent). Water scarcity is mentioned by migrants from Tudun Nufawa (20 percent) and Sabon Gari East (16.7 percent), reflecting the challenges associated with limited access to water resources. Extreme temperatures emerged as a significant push factor in Sabon Gari West (100 percent), reflecting the impact of climate-related hazards on migration decisions in this community. The influence of seasonal flooding events on migration patterns is confirmed by the mention of floods by migrants from Zango (14.3 percent).

There was no statistically significant difference in the perception of environment/climate-based push factors of migration across the communities ($H = 11.575$, $p = 0.115$) (Table D1). While the role of the environment/climate in driving migration is minimal (11 percent) (See Figure 4.37), factors such as drought and inadequate rainfall were considered the viable environment/climate-based drivers of migration (Figure 4.52).

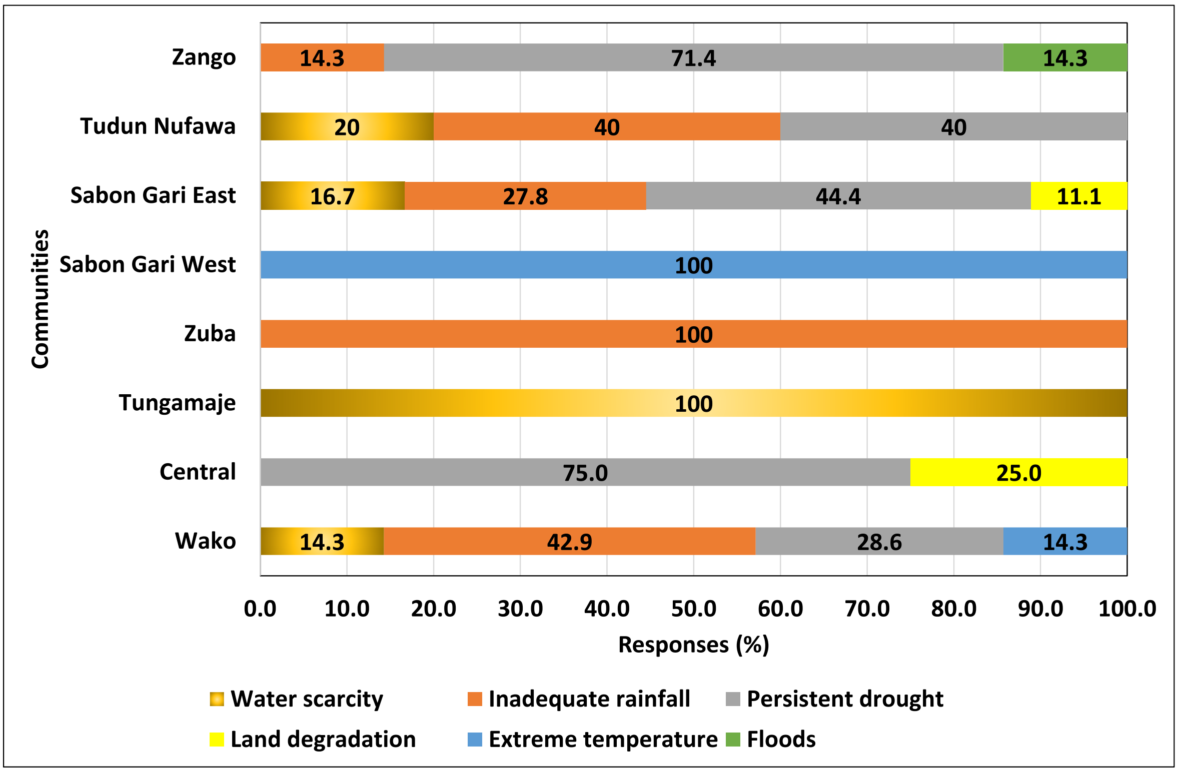


Figure 4.51: Climatic/Environmental Push Factors of Migration to Destination

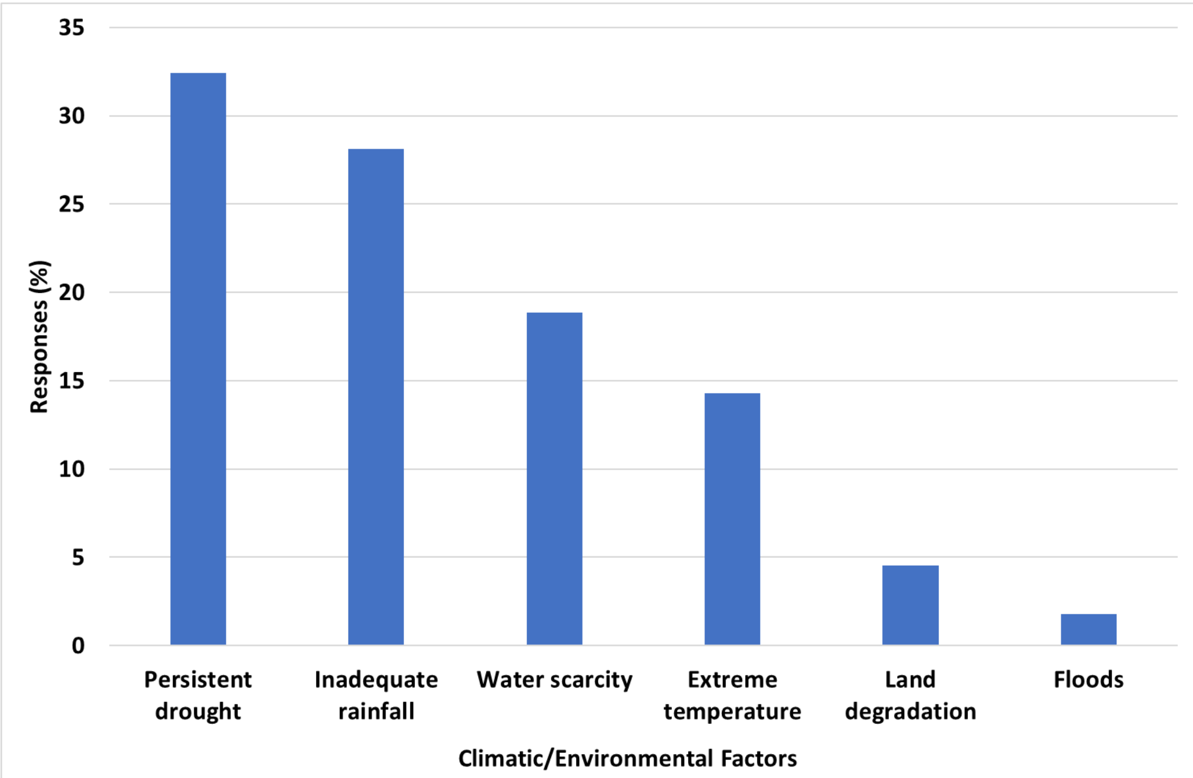


Figure 4.52: Ranking of Climatic/Environmental Push Factors of Migration to Destination

4.1.4.4 Environment/climate-based pull factors of migration

The environmental and climatic conditions of a given area play a pivotal role in determining the patterns of migration that attract migrants to it (pull factors). Communities can attract migrants due to the favourable environmental factors that they offer. Sabon Gari West (77.8 percent), Zuba (74.1 percent), Tungamaje (64.1 percent), and Sabon Gari East (60.8 percent) had the highest percentages of respondents perceiving good weather as the most influential factor that attracted them to their destinations (Figure 4.53). There were fewer respondents attesting to good weather in communities like Wako (16.7 percent) and Tudun Nufawa (21.9 percent). Tudun Nufawa had the highest percentage of respondents (53.1 percent) perceiving adequate rainfall as an environmental/climatic pull factor for migration, followed by Zango (44.1 percent) and Wako (41.7 percent). Soil fertility as a crucial factor in crop production was a notable migration pull factor to Wako (41.7 percent) and Central (22.2 percent), while few respondents perceived abundant pasture as a migration pull factor, with mentions from Central (16.7 percent) and Tungamaje (12.8 percent).

There was a significant variation in the perception of environmental and climatic pull factors of migration in the various communities ($H = 40.868$, $p < 0.05$) (Table D1). The post hoc test identified the significant pairwise variation between the communities, such as between Wako and Zuba ($H = 74.940$, $p < 0.05$), Sabon Gari West ($H = 80.392$, $p < 0.05$), Tungamaje ($H = 83.753$, $p < 0.05$); Tudun Nufawa and Zuba ($H = 64.289$, $p < 0.05$), Sabon Gari West ($H = 69.741$, $p < 0.05$), Central ($H = 71.307$, $p < 0.05$), Tungamaje ($H = 73.102$, $p < 0.05$); Zango and Sabon Gari West ($H = -54.438$, $p < 0.05$), Tungamaje ($H = -57.800$, $p < 0.05$) (Table D4).

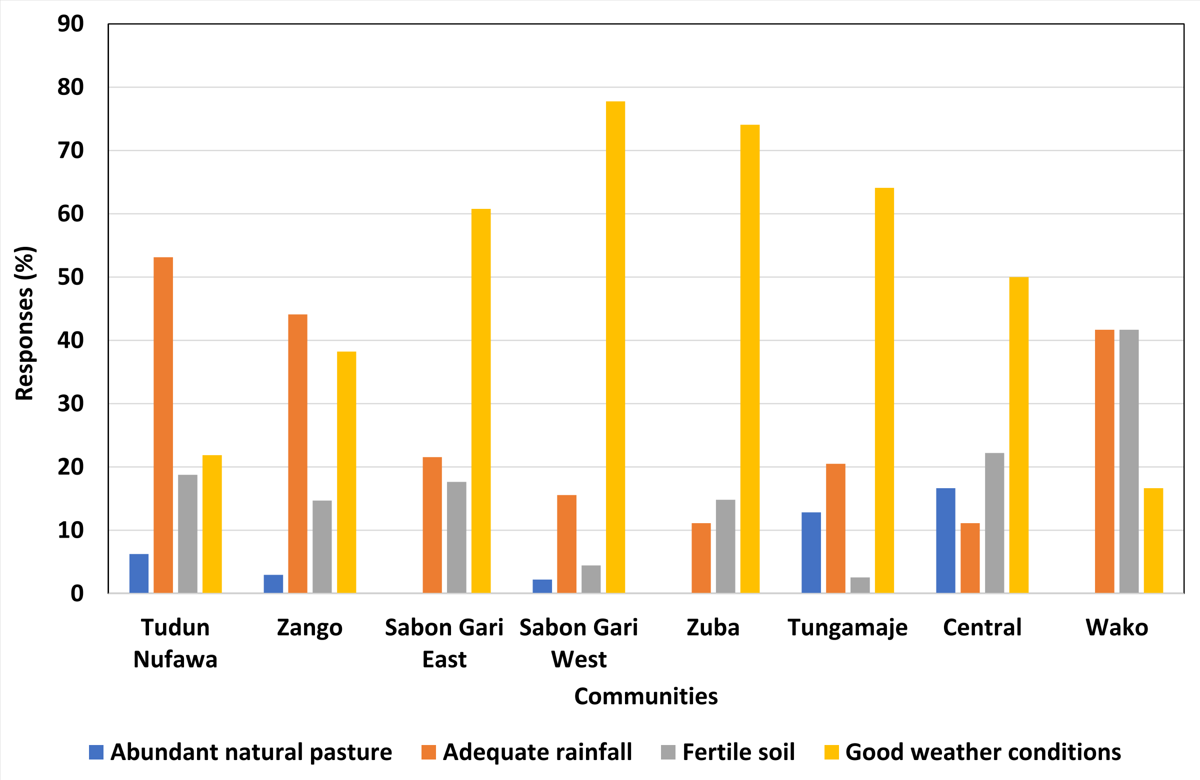


Figure 4.53: Climatic/Environmental Pull Factors of Migration to Destination

4.1.4.5 Perceptions of the causes of climate change

Climate change presents several challenges to communities across the globe, with diverse impacts on local environments and livelihoods. While local communities are the primary victims of climate change, their perceptions of its causes may differ depending on several socio-economic, cultural, and environmental factors. The responses of all respondents to the question of the causes of climate change were evaluated and are presented in Figure 4.54. The analysis of the survey data reveals a diversity of perceptions of the causes of climate change among respondents from the 12 communities. The perception of climate change as an act of God is particularly prevalent in Zango (41.4 percent), Zuba (44.5 percent), and Wako (30.1 percent) (Figure 4.54). Conversely, respondents from Tudun Nufawa (35.4 percent), Sabon Gari West (29.3 percent), and Central (14.8 percent) identified greenhouse gas emissions as a significant contributor to climate change. The perception of population increase as a cause of climate change is evident in several communities, with notable mentions in Odioma (14.9 percent), Ugborodo (25.2 percent), and Tudun Nufawa (38.4 percent). Similarly, deforestation was also cited as a cause in multiple communities.

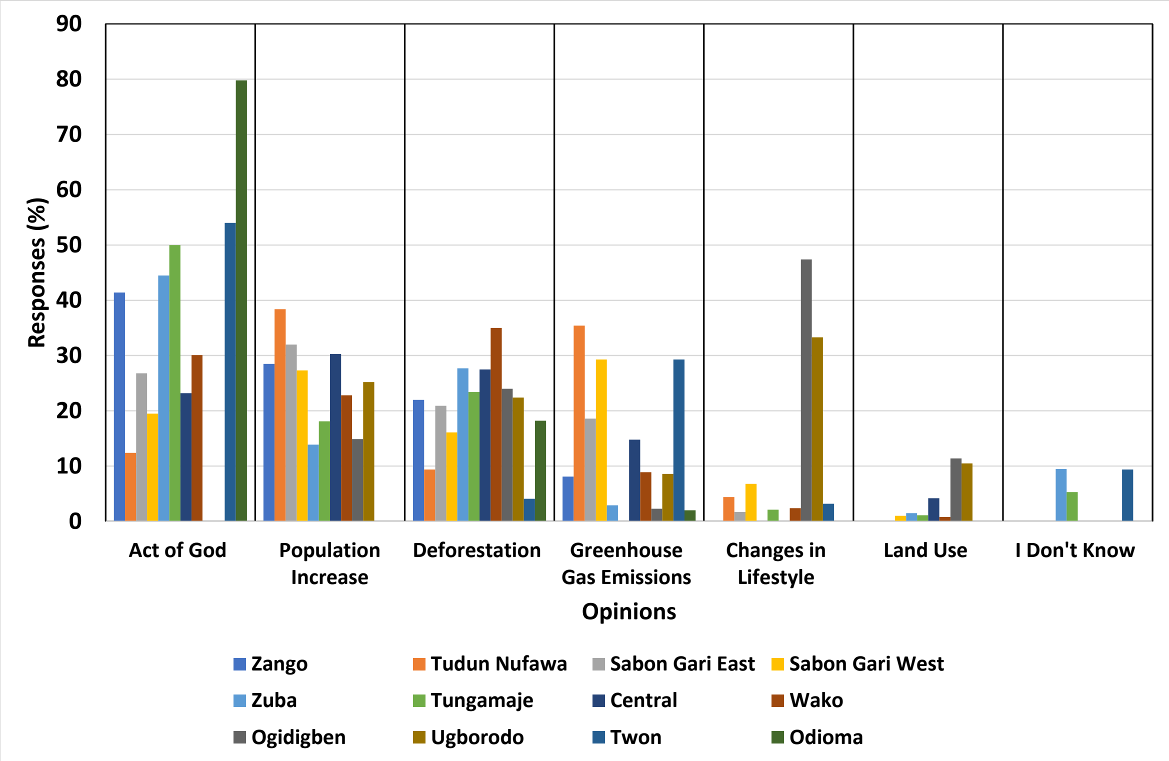


Figure 4.54: Perceptions of the causes of Climate Change

According to a discussant at Zango:

"The temperature increase is due to deforestation and built areas. The building congestion also prevents adequate air flow and ventilation".

A Tudun Nufawa discussant shared a similar opinion:

"The changes occur due to an increase in population and buildings. Unfortunately, there is no regulation or control over the way how people settle in this place. The temperature also increases due to deforestation and lack of trees. There is a need for more awareness regarding

this issue. All we can do is to pray for God to have mercy on us. The floods subside when the drainages are cleared but we have no one to clear it for us".

One of the stakeholders at Wako highlighted deforestation due to energy demands:

"Some of the causes are deforestation due to production of charcoal. Deforestation also affects the land quality. We hope the government can intervene and stop deforestation. There was a law preventing deforestation in the last 50 years but it is no longer implemented now. We still have laws to stop the cutting down of our shea butter trees but it is no longer implemented".

A discussant at Central highlighted something similar:

"Changes in rainfall has been experienced and it is due to the arrangement of God. Increase in temperature is also experienced due to deforestation".

4.1.5 Impacts of migration in the destination communities

4.1.5.1 Benefits of migration in the destination communities

The perceptions of migration benefits among respondents from the destination communities are presented in Figure 4.55. Economic prosperity emerged as a significant benefit in several communities, particularly in Zuba (38.9 percent), Sabon Gari West (31.3 percent), and Sabon Gari East (26.0 percent), reflecting the contribution of migrant labour to local economies. Improved security was identified as a benefit in several communities, including Tungamaje (47.8 percent), Zango (12.8 percent), and Sabon Gari East (26.0 percent), suggesting that migration plays a role in enhancing community safety and social stability. The increase in agricultural productivity is perceived as a benefit in multiple communities, which highlights the contribution of migrant labour to agricultural activities and food security. The respondents from several communities also mentioned the potential of sales for local products, which could provide opportunities for local businesses and stimulate economic growth. The availability of inexpensive labour was identified as a benefit in several communities, reflecting the role of migrant labour in meeting local labour demand and supporting economic activities. Social integration is perceived as a benefit in some communities, suggesting the potential for migration to promote cultural exchange and social cohesion. Nevertheless, respondents in some communities such as Zango (15.4 percent), Tudun Nufawa (25.7 percent), Sabon Gari West (10.4 percent), Tungamaje (15.6 percent), Central (38.7 percent), and Wako (53.3 percent) perceived no benefits of migration.

While most respondents did not perceive any migration benefits to their communities (23 percent), they alluded to improved markets for local products, security and agricultural productivity (an average of 16 percent each) (Figure 4.56). The varying perception of benefits derived by communities due to migration was significant ($H = 110.590$, $p < 0.05$) (Table D1). The post hoc test identified the significant pairwise variation between the communities, namely Sabon Gari West-Tungamaje ($H = 96.803$, $p < 0.05$), Sabon Gari East-Tungamaje ($H = 78.812$, $p < 0.05$), and Zuba-Tungamaje (73.094, $p < 0.05$) (Table D5).

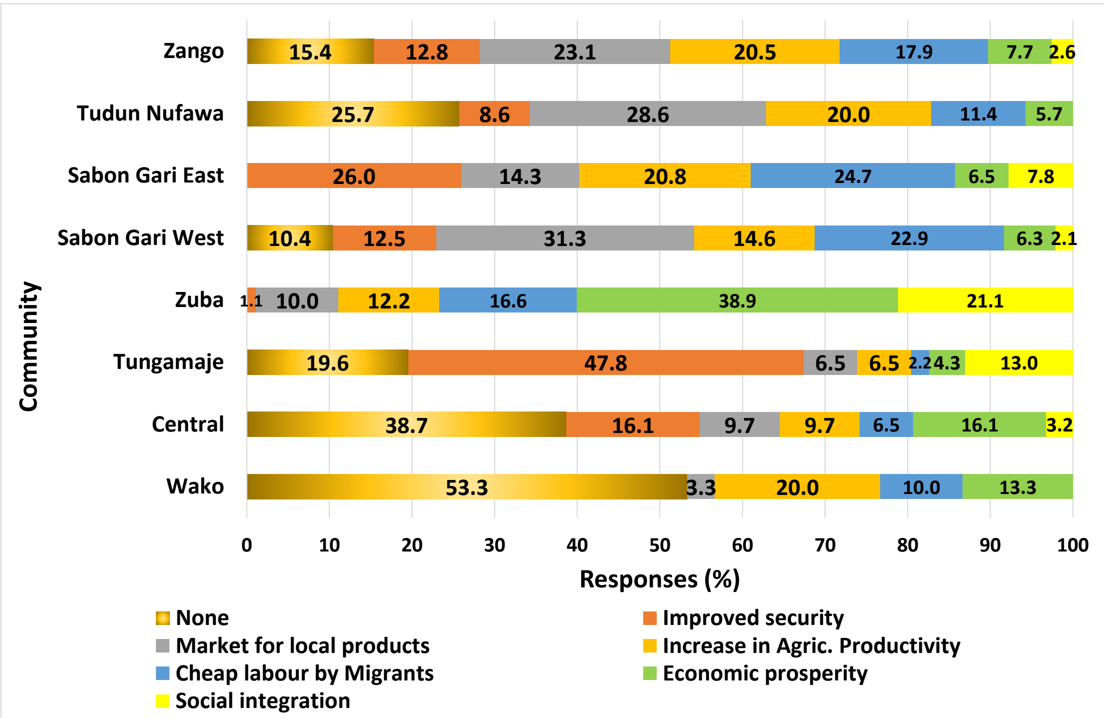


Figure 4.55: Benefits of Migration in the Destination Communities

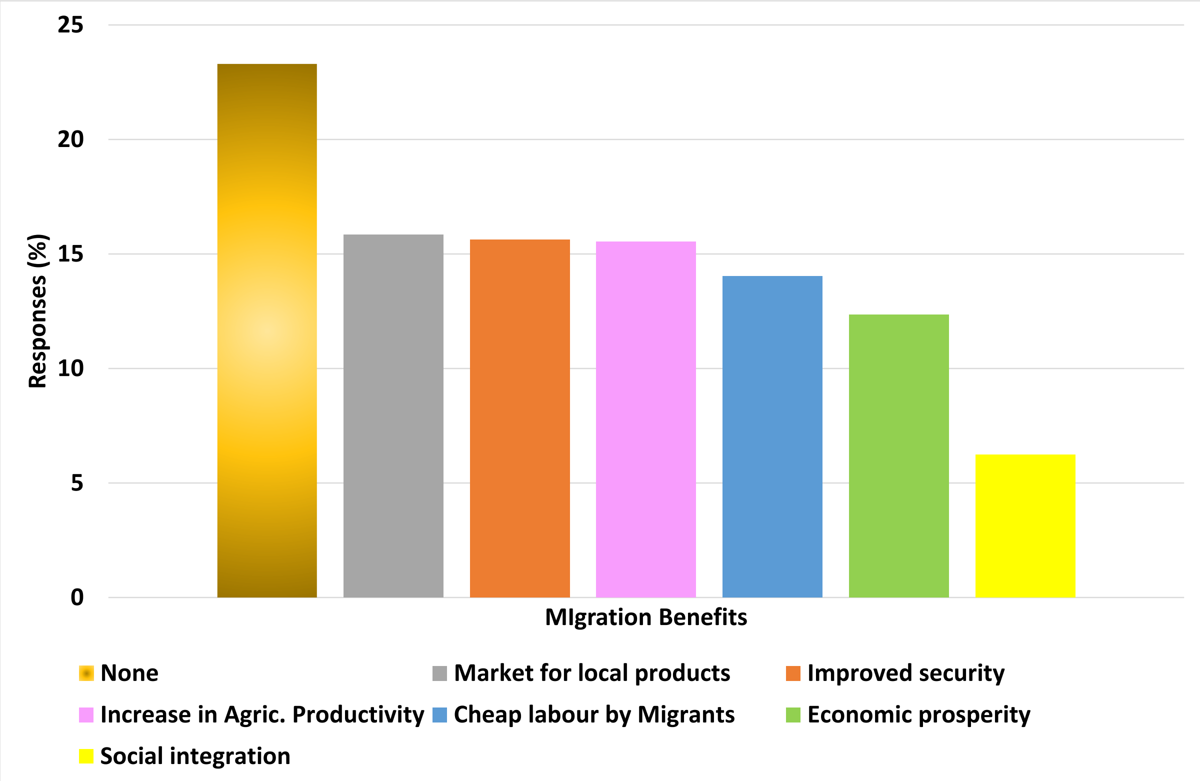


Figure 4.56: Ranking of Migration Benefits for Destination Communities

4.1.5.2 Challenges of migration in the destination communities

While migration can contribute to economic prosperity, the availability of cheap labour by migrants and the increase in agricultural productivity are two factors that can be considered beneficial. However, it is important to acknowledge that migration can also present challenges that may strain local resources and social cohesion. Figure 4.57 illustrates the perceptions of migration challenges among respondents from the eight destination communities. The most significant challenge identified in several communities was the competition for jobs (Figure 4.57), which was particularly evident in Wako (77.3 percent), Central (73.3 percent), and Sabon Gari East (52.2 percent), reflecting concerns about labour market pressures and economic opportunities.

In addition, the concept of insecurity was identified as a challenge in several communities, including Sabon Gari West (55.6 percent), Tungamaje (53.8 percent), and Zango (28.6 percent). This highlights the impact of migration on conflicts and social stability. The respondents from multiple communities also highlighted the issue of pressure on agricultural lands and pressure on environmental resources being the third and fourth most pressing challenges posed by migration on destination communities. In addition to the concerns about the sustainability of natural resources and ecosystem services due to migration, land degradation was perceived as a challenge at Zuba, Tungamaje, Sabon Gari Eat and Sabon Gari West. This reflects an awareness of the environmental degradation associated with migration-induced land-use practices and urbanisation. Lastly, the respondents from Central (10.0 percent) and Zango (11.4 percent) identified the issue of pressure on land for development which happened to be the least average migration challenge on the destination communities. On average, the competition for jobs was the biggest challenge faced by the destination communities (44 percent), followed by insecurity (23 percent) and pressure on agricultural lands (12 percent). Communities also faced the issue of pressure on environmental resources (11 percent), land degradation (7 percent) and pressure land for development (3 percent) (Figure 4.58).

There was a statistically significant variation in the perception of various community challenges due to migration ($H = 41.729$, $p < 0.05$) (Table D1). The post hoc test identified the significant pairwise variation between the communities, namely, Sabon Gari West-Tungamaje ($H = -104.739$, $p < 0.05$), Central-Tungamaje ($H = 102.445$, $p < 0.05$), Sabon Gari East-Tungamaje ($H = -97.942$, $p < 0.05$), Central-Tungamaje ($H = 102.445$, $p < 0.05$) and Zuba-Tungamaje ($H = 97.431$, $p < 0.05$) and Wako-Tungamaje ($H = 97.092$, $p < 0.05$) (Table D6).

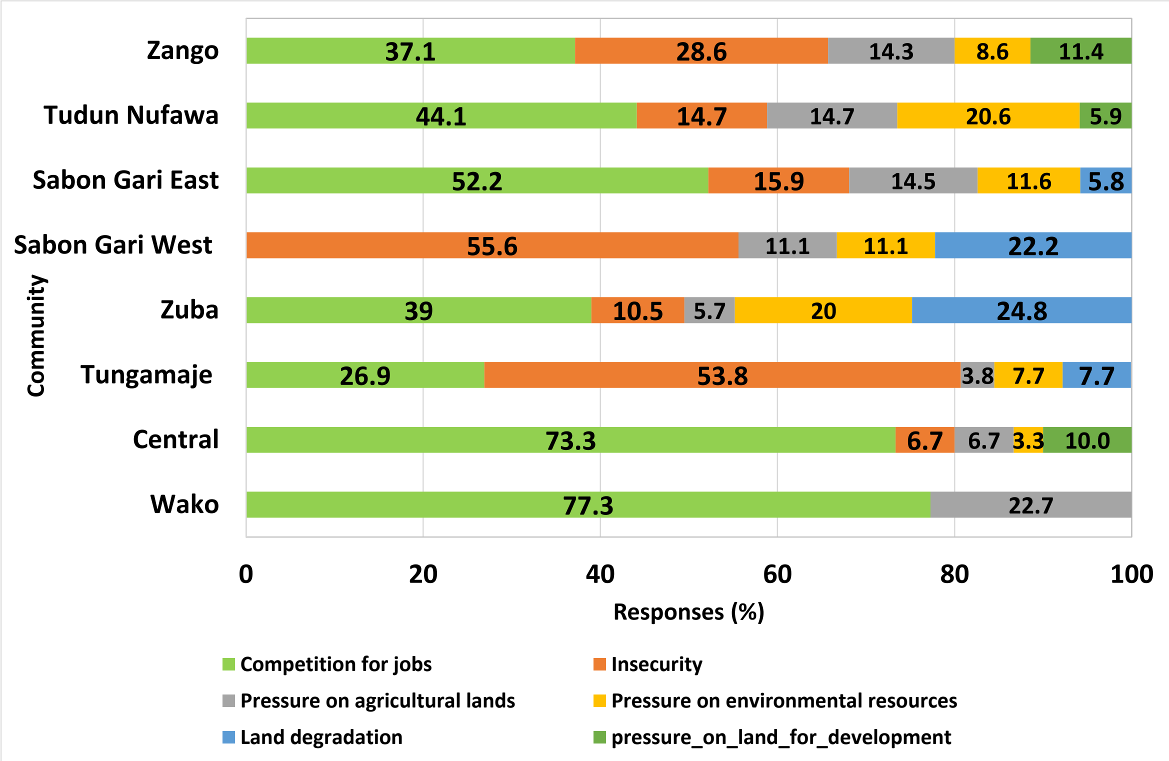


Figure 4.57: Challenges in Communities of Destination due to Migration

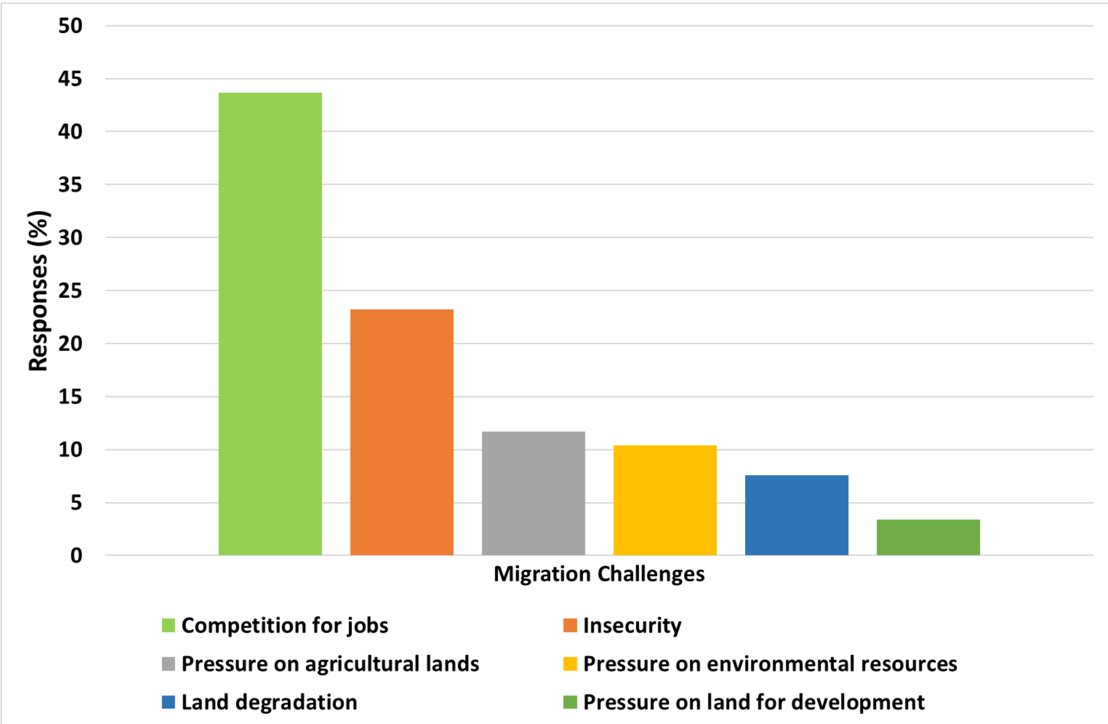


Figure 4.58: Ranking of Challenges at Destination Communities due to Migration

The emphasis among Sabon Gari West stakeholders was all about temperature due to urban growth. According to one of the discussants:

"For the past 30 years, rapid developments began to take place here unlike in previous times when the population was not as much as it is now and there was no congestion of buildings. The flooding does not affect our livelihood as much unless when the rainy season is at its peak and it affects us".

A stakeholder at Wako had mixed feelings about migration in his community:

"In-migration has both advantages and disadvantages. While it has led to the boosting of the economy, the migrants have led to an increase in various forms of pollution. The community leaders and indigenes are working hard to control the activities of the migrants such that their pollution will not have adverse effects on the community".

4.1.5.3 Land degradation challenges of migration at the communities of destination

Respondents at the communities affected by migration-induced land degradation perceived different land-degrading activities within their communities. Pressure on land for development was the major concern in Sabon Gari West and Sabon Gari East (59.5 percent and 71.7 percent, respectively) (Figure 4.59). Deforestation and vegetation loss were also concerns in Sabon Gari West, with 35.1 percent of respondents identifying this as a key issue. In Tungamaje, pressure on agricultural lands and pressure on land for development were equally cited as the main challenges by 50 percent of respondents. Notably, in Zuba, deforestation/vegetation loss was overwhelmingly identified as the only challenge, with 100 percent of respondents expressing concerns about this issue. On average, pressure on land for development and deforestation/vegetation loss were the two highest factors of land degradation. There was no significant difference in perceptions of migration as a reason for land degradation ($H = 6.853$, $p = 0.077$) (Table D1), as the communities generally agreed on the common activities leading to land degradation.

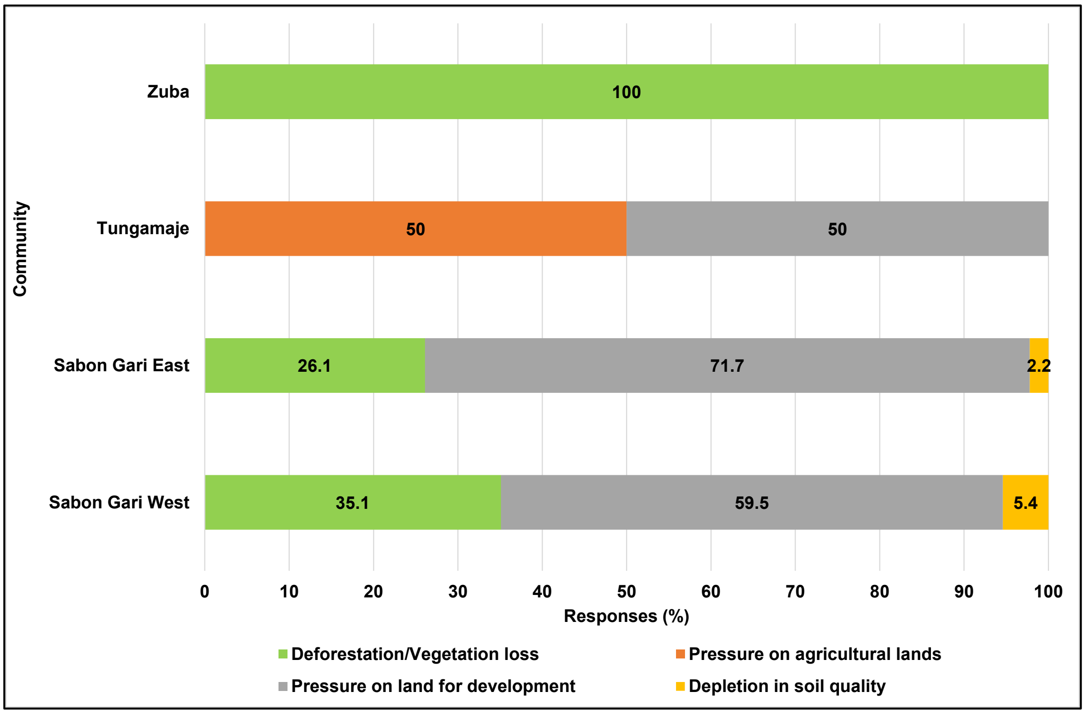


Figure 4.59: Perception of Land Degradation Challenges due to Migration

The average proportion of respondents who strongly agreed and agreed that migration contributed to land degradation was 29.5 percent and 41.1 percent, respectively, while 18.4 percent were neutral (Table 4.13). There was no significant difference in these levels of agreement among respondents from the different communities (H = 4.010, p = 0.260) (Table D1). This was confirmed by the participants at the FGDs, who unanimously agreed that most land degradation activities were consequences of population pressure caused by the influx of migrants into their communities.

Table 4.13: Perception of Migration as a Cause of Land Degradation

Option	Sabon Gari East	Sabon Gari West	Zuba	Tungamaje	Average
Strongly agree	35.6%	33.3%	28.9%	20.0%	29.5%
Agree	42.2%	42.2%	37.8%	42.2%	41.1%
Neutral	15.6%	17.8%	20.0%	20.0%	18.4%
Disagree	4.4%	4.4%	11.1%	15.6%	8.9%
Strongly disagree	2.2%	2.2%	2.2%	2.2%	2.2%

The NDVI and NDBI in the Sabon Gari East and Sabon Gari West communities of Fagge LGA exhibited spatial and temporal variations between 2014 and 2023 (Figures 4.60 and 4.61). There were considerable variations in the NDVI and NDBI over the years (Figure 4.61). A decline in vegetation was observed in the northern region of the larger surroundings of the investigated communities (in Fagge LGA) (Figure 4.60a, b) and replaced by increased built-up areas (Figure 60c, d), indicating intense densification. The summary statistics of these indices (Table 4.14) and a view of the Google Earth images of both communities in 2014 (Plate Ia) and 2023 (Plate Ib) confirm the increase in the built-up areas, particularly in Sabon Gari West, and the minimal presence of green spaces and changes in vegetation. Meanwhile, both communities exhibited comparable temporal patterns of increased built-up areas, with Sabon Gari West experiencing a notably larger proportion than Sabon Gari East (Figure 4.59c, d).

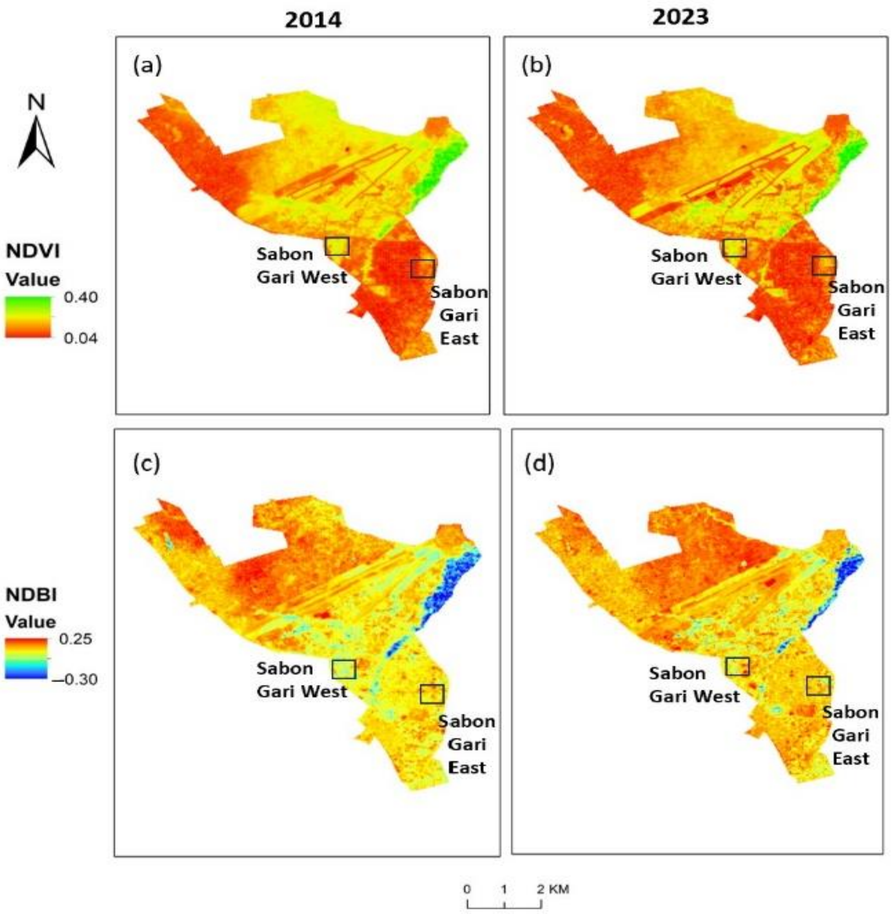
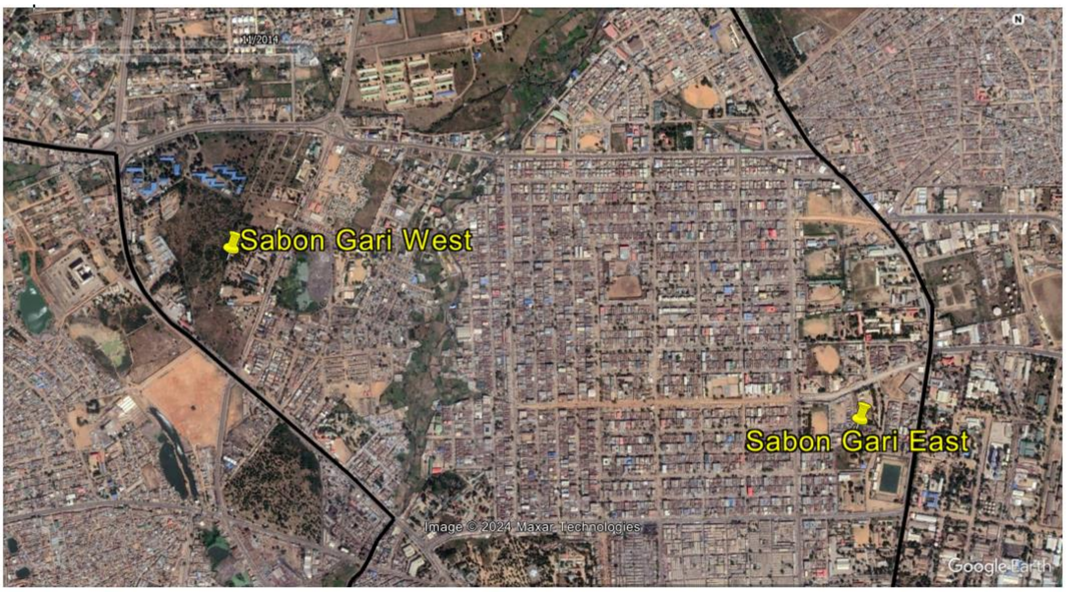


Figure 4.60: Spatial Distribution of NDVI (a, b) and NDBI (c, d) at the Study Locations in Fagge in 2014 and 2023

(a)



(b)

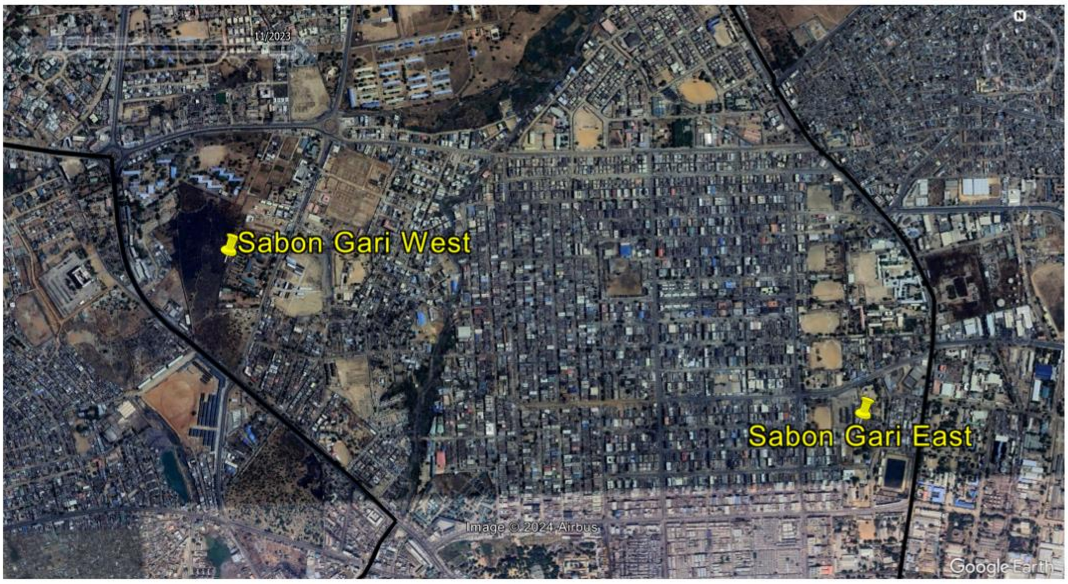


Plate I: Built-up areas at Sabon Gari East and Sabon Gari West of Fagge LGA in (a) 2014 and (b) 2023
(Source: Google Earth, 2024)

Table 4.14: Summary of NDVI and NDBI Distributions at the Study Locations

Location	Parameter	Year	Mean	Minimum	Maximum	SD
Sabon Gari East	NDVI	2014	0.05	0.02	0.15	0.02
		2023	0.05	0.00	0.19	0.03
	NDBI	2014	0.02	−0.02	0.08	0.01
		2023	0.03	−0.07	0.11	0.02
Sabon Gari West	NDVI	2014	0.10	0.04	0.18	0.03
		2023	0.10	0.02	0.22	0.04
	NDBI	2014	0.01	- 0.07	0.08	0.02
		2023	0.03	- 0.05	0.19	0.03
Zuba	NDVI	2014	0.16	0.04	0.28	0.05
		2023	0.14	0.03	0.32	0.05
	NDBI	2014	0.02	−0.18	0.15	0.04
		2023	0.04	−0.14	0.15	0.03
Tungamaje	NDVI	2014	0.16	0.06	0.30	0.05
		2023	0.16	0.04	0.33	0.05
	NDBI	2014	0.02	−0.16	0.20	0.04
		2023	0.02	−0.17	0.23	0.03

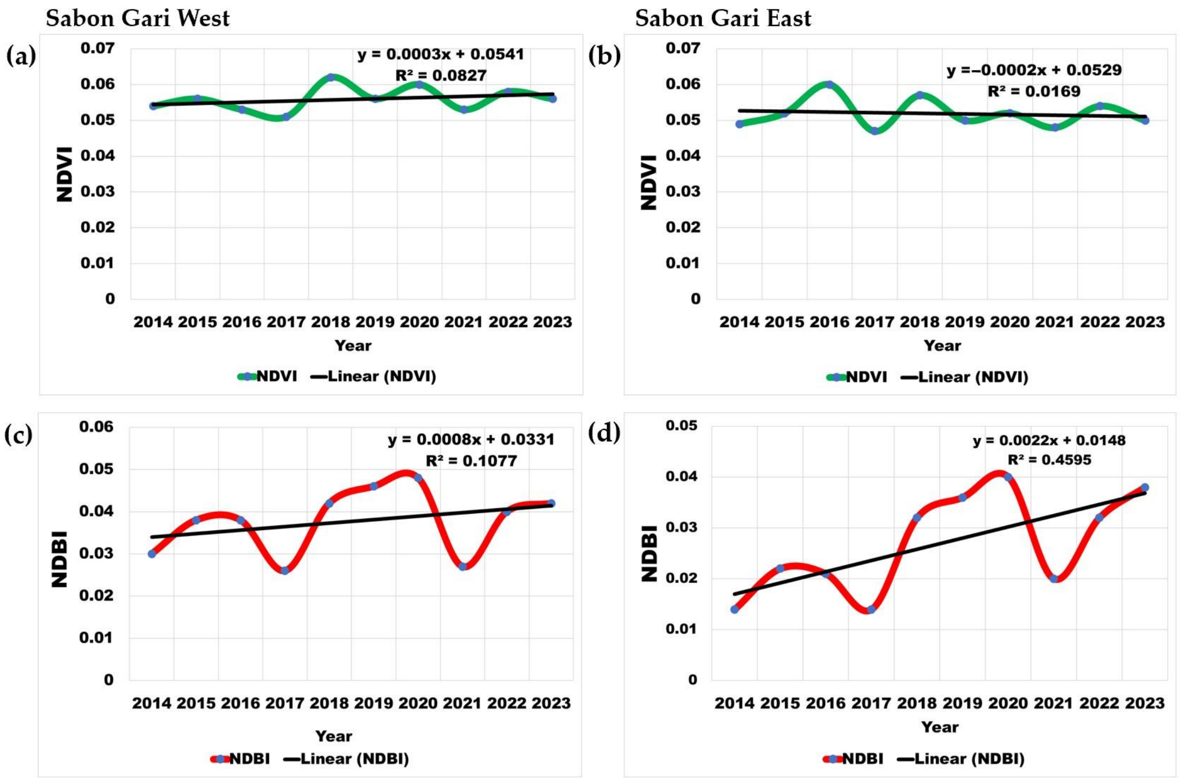


Figure 4.61: Temporal Variations in NDVI (a, b) and NDBI (c, d) at Sabon Gari West and Sabon Gari East in 2014 and 2023

The vegetation patterns in the Zuba and Tungamaje communities of Gwagwalada LGA (Figures 4.62 and 4.63) were similar to those observed in Fagge LGA. The NDVI indicated a decline in vegetation cover in Zuba, whereas Tungamaje exhibited minimal changes in vegetation between the study years. Despite the apparent stability of the vegetation cover, Tungamaje exhibited a higher rate of built-up expansion and densification of settlement bodies, a result similar to that observed in Sabon Gari West. In contrast, Zuba demonstrated a slight increase in the expansion of built-up areas. The descriptive summary statistics of these indices (Table 4.14) and a view of the Google Earth images of Zuba and Tungamaje in 2014 (Plate IIa) and 2023 (Plate IIb) indicate an increase in built-up areas, particularly in Tungamaje. The built-up areas in Zuba were already well-established in 2014.

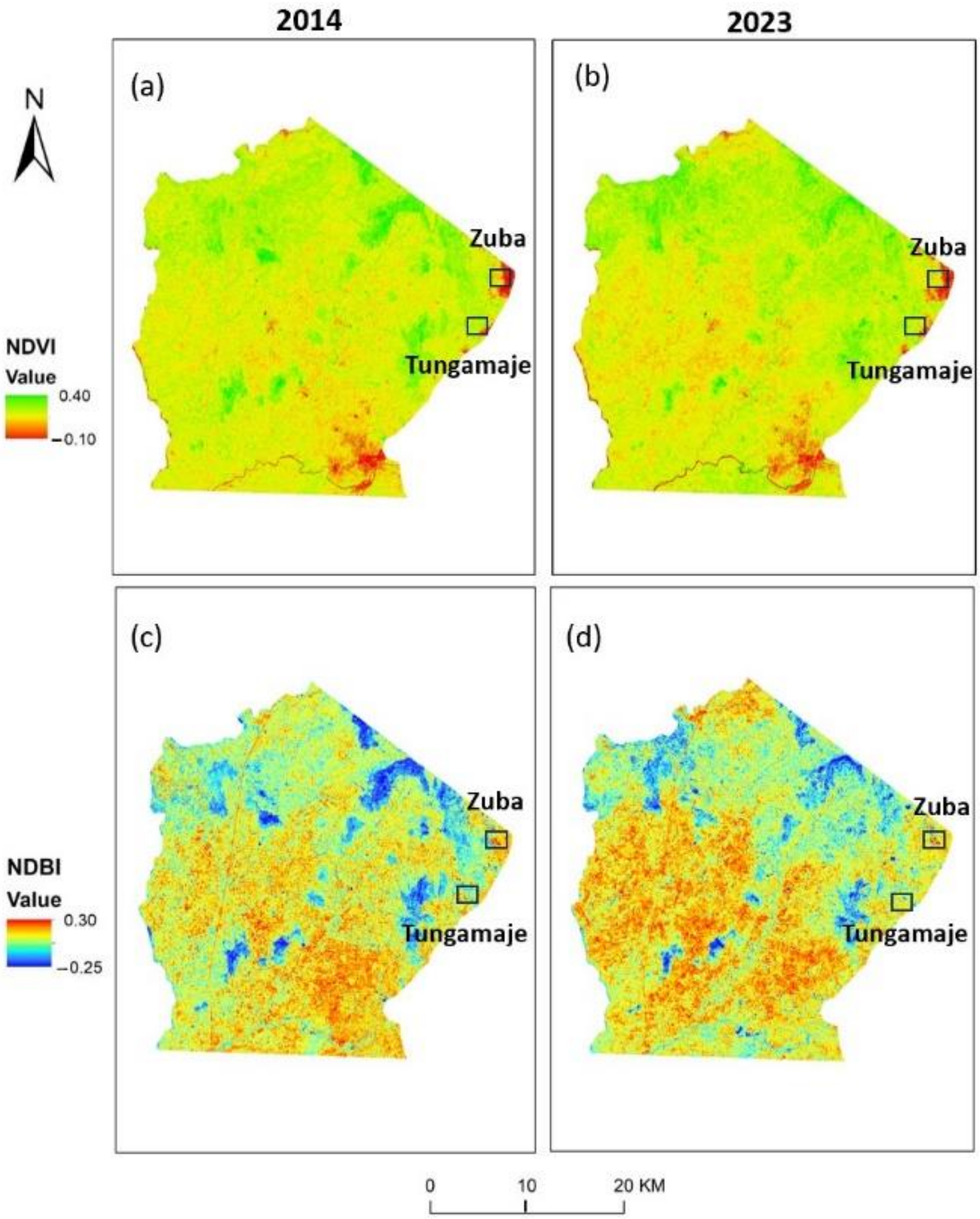


Figure 4.62: Spatial Distribution of NDVI (a, b) and NDBI (c, d) at the Study Locations in Gwagwalada in 2014 and 2023

(a)

(b)

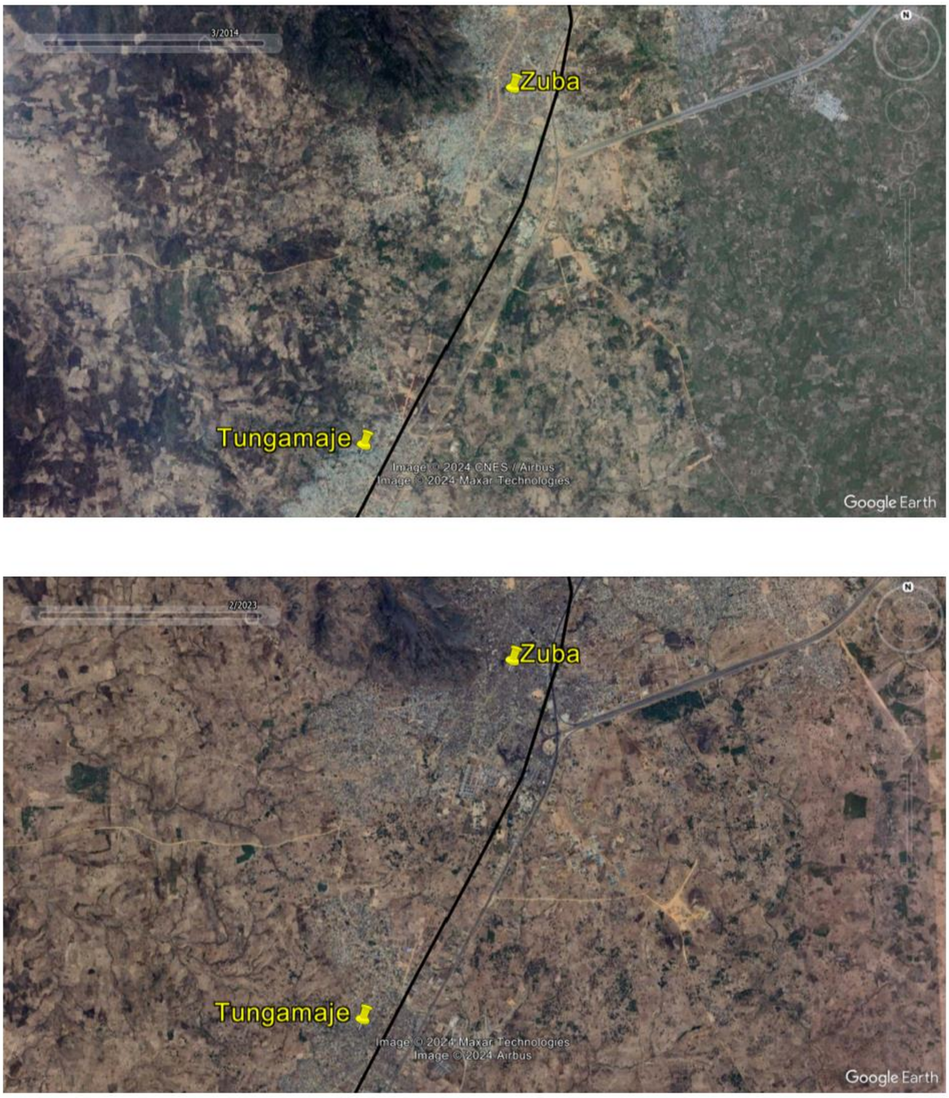


Plate II: Built-up areas in Zuba and Tungamaje of Gwagwalada LGA in (a) 2014 and (b) 2023

(Source: Google Earth, 2024)

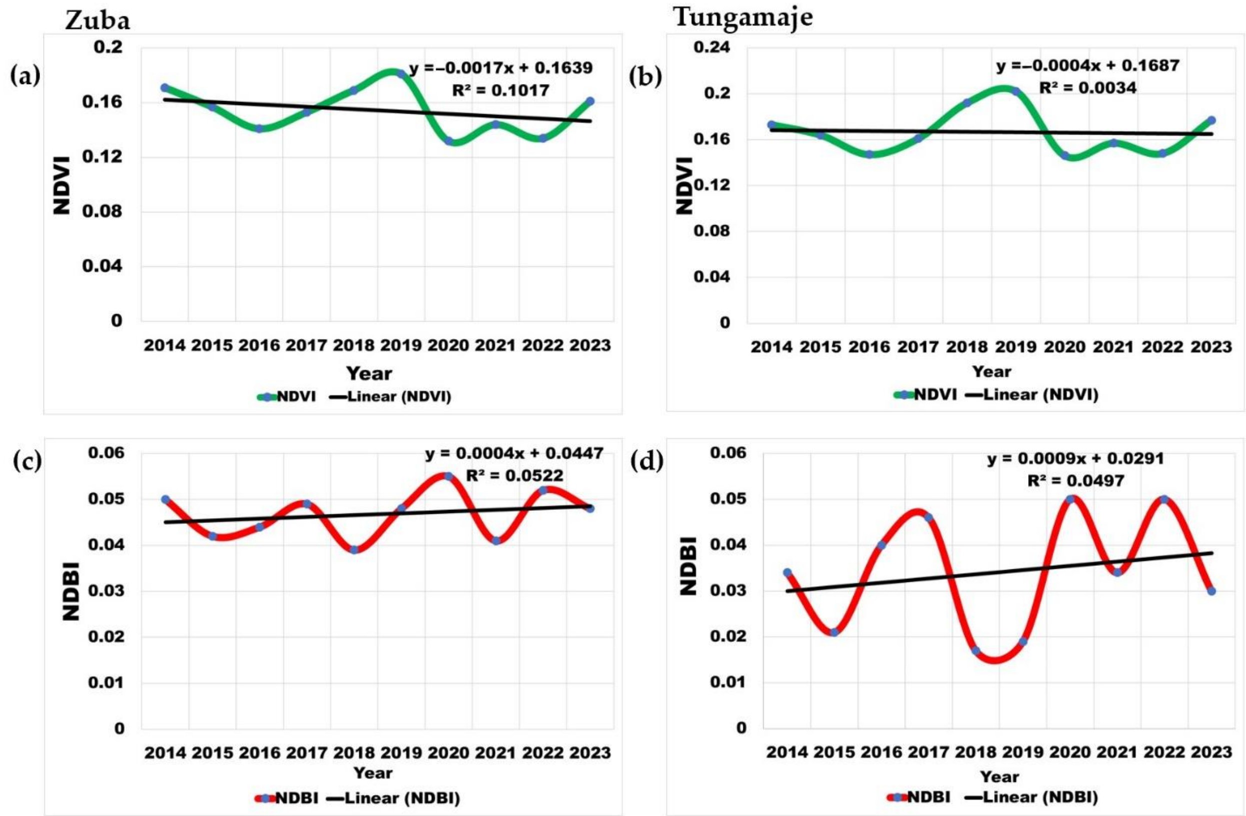


Figure 4.63: Temporal variations in NDVI (a,b) and NDBI (c,d) in Zuba and Tungamaje in 2014 and 2023

To reconcile the remotely sensed land degradation processes with local knowledge of the various activities leading to land degradation, the multinomial logistic regression model produced Nagelkerke R^2 values of 0.166 (Sabon Gari East), 0.225 (Sabon Gari West), 0.391 (Zuba), and 0.221 (Tungamaje) (Table D1). In Sabon Gari East, Sabon Gari West, and Tungamaje, the pressure on land for development (for urban growth and infrastructure expansion) significantly contributed to land degradation. Meanwhile, deforestation/vegetation loss substantially contributed to the observed land degradation at Zuba (Table D2). These findings align with the local perceptions of land degradation, which identified built-up expansion as a major issue in Sabon Gari East, Sabon Gari West, and Tungamaje. Meanwhile, deforestation was a key concern in Zuba.

An FGD participant from Sabon Gari East confirmed the pressure on land for development (Plate IIIa):

We often experience flooding because of the influx of traders and the rapid increase in shopping complexes and business centres. This is worse because of the poor sewage disposal system, which has blocked the waterways. The lack of proper drainage has resulted in water runoff into our homes and businesses, and we cannot do anything about it. A rainfall period of one hour can cause everywhere to be submerged in water.

Chopped logs and charcoal, the by-products of logging, were used to meet the growing energy demands in Zuba (Plates IIIb, c). One of the FGD participants confirmed this statement:

For some decades now, the increase in population due to the influx of migrants has led to the cutting down of our trees to produce charcoal as fuel for cooking. This has exposed our environment, and the temperature is increasing. We hope that the government will do something about this situation.

At Tungamaje, a participant at the FGD explained:

Due to the rapid development rate in our community, migrants come in and buy our lands from the government without our knowledge. We would wake up one day and discover that our farmlands had been cleared, the trees had been removed, and a new owner was building on it. We often have intense fights with impostors to defend our farmlands.

Plate III: (a) Improper sewage disposal along a drainage system at Sabon Gari East. (b) Stacking of chopped logs in Zuba. (c) Sale of charcoal, a major cooking fuel in Zuba (Source: Author's fieldwork, 2023)

4.1.5.4 Perception of the responsibility for leading interventions on climate and environment-induced migration

The analysis of household heads' perceptions regarding who is responsible for leading interventions on the climate and environment-induced migration reveals diverse preferences across the surveyed communities. In Zango, Tudun Nufawa, Sabon Gari East, Sabon Gari West, Zuba, Tungamaje, Central, Wako, Ogidigben, and Odioma, a majority of respondents expressed a preference for government agencies to lead interventions, with percentages ranging from 38.8 percent to 66.4 percent (Figure 4.64). However, community leaders are also perceived as notable leaders in several communities, with percentages ranging from 15.1 percent to 33.0 percent. Politicians had some mention in some communities, ranging from 4.3 percent to 39.6 percent. NGOs and religious bodies are perceived as less prominent leaders across most communities, with varying levels of support.

There was a significant variation in the perception of who takes responsibility for leading interventions on climate and environment-induced migration in the various communities (H = 37.327, $p < 0.05$) (Table D1). The post hoc test identified the significant pairwise variation between the communities. The significant variation between each community is illustrated in Table D7.

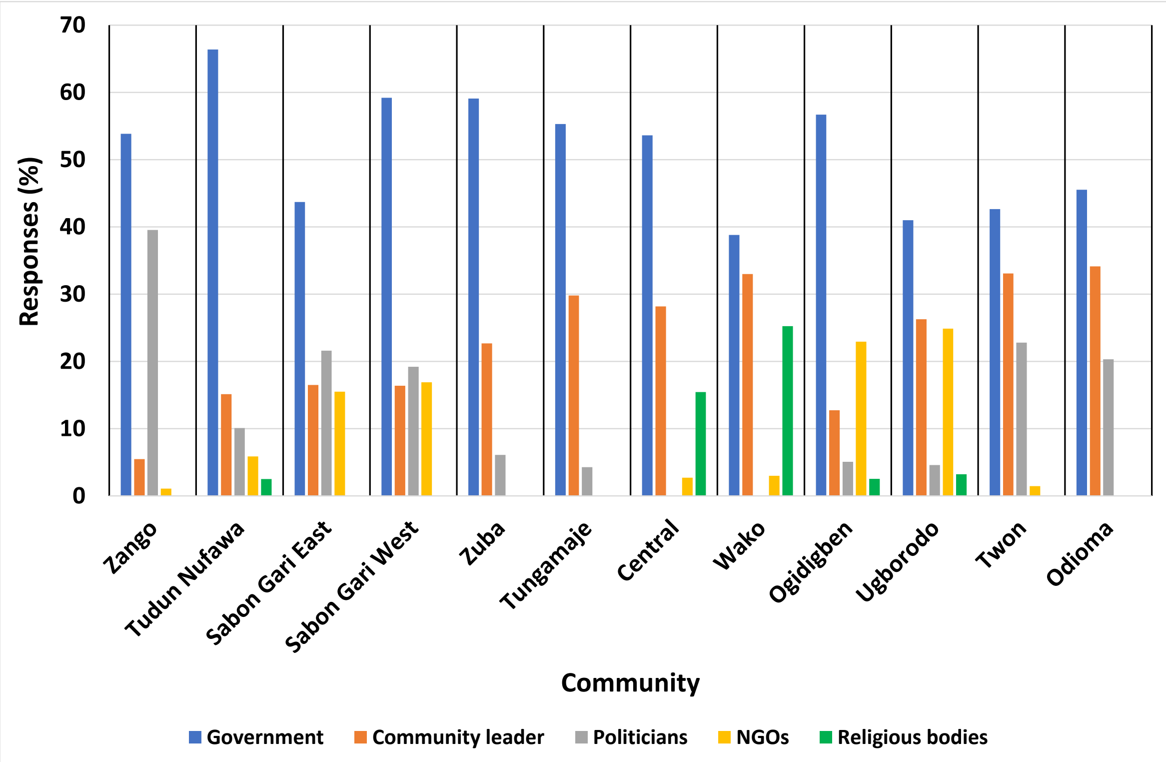


Figure 4.64: Responsibility of who leads Intervention Discussions on Climate and Environment-Induced Migration

Most of the responses from the various FGDs called out the government for taking responsibility for dealing with the climate and environment-induced migration (Table 4.15).

Table 4.15: Emerging Themes on the Efforts in Leading Interventions on Climate and Environment-induced Migration

Theme	Community	Extracts of Participants' Responses
Government	Zango	They are doing nothing about it. They only set up community development committees, and they are not effective.
	Tudun Nufawa	We need their intervention. Nothing has been done yet.
	Sabon Gari East	Any intervention is based on the political interest of the government in power.
	Sabon Gari West	The government needs to develop adequate land use plans to curb pressure on lands and environmental degradation caused by the continuous influx of migrants into the community.
	Central	The Area Council encourages afforestation and creates awareness programmes for tree planting.
	Wako	The Government Agencies are trying their best in our communities.
	Ogidigben	Some strategies are yet to be executed by the government
	Ugborodo	The government has been negligent of the environmental challenges
	Twon, Odioma	The government sets up barriers to minimise coastal flooding. However, these barriers need stronger reinforcements as they are often overwhelmed by the rising sea level.

4.2 Discussion of Results

The analysis of temperature indicated a significant increase over 30 years across all the study locations, which is consistent with global warming trends that directly affect agriculture and food security (Betts *et al*., 2018). The significant increase in temperature leading to food insecurity in the SSEZ is consistent with previous studies (Butu and Emeribe, 2019; Yamusa and Abdulkadir, 2020). The same can be said for the Guinea Savanna (Tarfa *et al*., 2019; Aturamu *et al*., 2021) and the MFCV (Ayeku, 2022). The consistent increase in temperature not only affects agricultural activities (Olufemi *et al*., 2020) but also exacerbates issues related to heat stress among humans (Raimi *et al*., 2021) and animals (Oke *et al*., 2021), and energy demands (Elias and Omojola, 2015). It can also increase evaporation rates, which alters the local hydrological cycle, thereby producing devastating impacts on the local ecosystem and human settlements (Raimi *et al*., 2021).

Unstable rainfall patterns and fluctuating rainfall dynamics are evident across the study locations. This aggravates the issues of food insecurity and poverty (Olayide and Alabi, 2018; Sanchi *et al*., 2024). A notable decrease in precipitation levels was observed at Warri South West and Brass. This has been attributed to a southward shift in the divide between the double and single rainfall peaks and a temporal change in the little dry season, which moved from August to July (Ojekunle *et al*., 2014).

The annual sea level rise of 3.04 mm over 22 years at the Nigerian coasts is significant and poses serious risks to coastal communities, infrastructure, and ecosystems. This increase aligns with the global patterns of sea level rise driven by the melting ice caps and thermally expanding seawater due to global warming (Hansen *et al*., 2020). The substantial variability indicated by the standard deviation and range demonstrates the difficulty of forecasting annual sea level fluctuations. The slight positive skewness indicates a tendency toward increased sea level rise in recent years, which could indicate accelerated trends. These findings emphasise the necessity of implementing adaptive measures to mitigate the impacts of sea level rise.

The significant increase in the negative anomalies across the migration origin locations in the Savannah region of Nigeria (Kano Municipal and Kwali) indicates an increase in the frequency of droughts. This trend can be attributed to the temperature and precipitation pattern shifts. These changes may affect vegetation growth and agricultural productivity. In addition, rapid urbanisation and deforestation have altered the landscape and reduced vegetative cover at these locations (Ibrahim, 2017; Mohammed *et al*., 2019). In the coastal region, low values of vegetation health were observed. This reflects the region's challenges, such as soil degradation, biodiversity loss, and increased susceptibility to environmental hazards, which may be attributed to oil exploration activities, deforestation, and urban expansion, which exert significant pressure on local vegetation (Onyena and Sam, 2020).

The various migration motivations highlight the complex interplay of economic, environmental, social, and individual factors that shape migration patterns. The search for job opportunities was the major migration driver, with migrants seeking enhanced prospects for employment in their prospective destination areas, reflecting the importance of job prospects in driving migration decisions. This highlights the importance of labour market dynamics in shaping migration patterns. Business and trading opportunities were perceived as significant motivations, particularly in communities with thriving commercial activities, where migrants seek to fulfil their dreams of entrepreneurship and enhanced financial capacity. The major influence of socioeconomic drivers of migration aligns with previous studies (Agwu *et al*., 2020; Akanle and Ola-Lawson, 2022; Ezeudu and Tukur, 2024). Meanwhile, climate and environment came a distant third, based on the level of influence. These climate/environmental drivers include flooding, inadequate farmlands, land degradation, sea level rise, and drought. This reflects the vulnerability of certain areas to ecological challenges that can influence migration, as asserted (Teye, 2022). In addition, respondents from some communities identified socio-cultural ties and adventure as factors affecting migration. This highlights the significance of social and personal factors in migration decision-making processes. Based on previous studies, societal ties and personal preferences can influence migration decisions. Individuals consider several factors when making this decision, including family connections, cultural affinity, and the desire for new experiences (Czaika and Reinprecht, 2022). Furthermore, the availability of land and concerns about insecurity may act as a driving force behind migration from certain communities, reflecting broader socioeconomic and political dynamics (Van Hear *et al*., 2020).

The significant variation in specific migration motivation varies across communities, indicating the distinctive challenges faced by each community. This highlights the multifaceted factors that drive migration, affirming the need to develop targeted interventions that address communities' specific needs and promote sustainable development. In communities with security concerns, insecurity is perceived as a motivating factor for migration. This underscores the impact of safety and stability on migration patterns, similar to other climes (Faret *et al*., 2021). Education, historical ties, and sociocultural factors are perceived as less prominent motivations, although they may still influence migration decisions in specific contexts.

The perceived benefits of migration include enhanced security, improved financial circumstances, and acquiring new skills. Migrants in Zuba viewed migration favourably, possibly due to the perceived improvements in their livelihoods. This can be influenced by access to resources and improvements in socioeconomic infrastructure. Despite the benefits, respondents perceived migration challenges, demonstrating the complex interplay of social, economic, and environmental factors that shape community dynamics. The issue of job competition is a major concern, once again establishing the impact of migration on local labour markets and livelihood opportunities. Insecurity emerges as a significant challenge, emphasising the necessity for interventions to address social tensions and promote community cohesion. This is consistent with previous studies citing insecurity as a significant challenge to migration, especially in Nigeria (Adofu and Alhassan, 2018; Eneji and Agri, 2020). The pressure on agricultural lands and environmental resources reflects concerns about the sustainability of natural resource management and the resilience of ecosystems despite population pressures and land-use changes. The perception of land degradation as a challenge reveals the necessity of implementing sustainable land management practices and conservation efforts to mitigate environmental degradation. The pressure on land for development illustrates the tensions between urbanisation and land conservation, emphasising the importance of balanced land-use planning and sustainable development strategies.

The perceptions of environmental and climatic push factors among migrants pointed out inadequate rainfall (in Zango, Tudun Nufawa, Sabon Gari East, Zuba, and Wako) and persistent drought (in Zango, Tudun Nufawa, Sabon Gari East, Central and Wako) as the major environment and climate-based migration push factors, while water scarcity was cited as a push factor in some other communities (in Tudun Nufawa, Sabon Gari East, Tungamaje and Wako). This highlights the importance of water management and adaptation strategies in addressing migration pressures, as revealed in previous studies (Hoffmann *et al.*, 2021; Stoler *et al.*, 2022; Xu and Famiglietti, 2023). Some migrants in communities such as Sabon Gari West and Zuba have identified the influence of floods on migration decisions.

Considering the various perceptions of environmental and climatic pull factors of migration, adequate rainfall and good weather conditions were the key pull factors for all communities. The perception of fertile soil as a pull factor in all communities also highlights the role of opportunities for crop farming in migration decision-making. Migrants in Central and Tungamaje identified the availability of abundant natural pasture as a key factor influencing their migration decisions, affirming that livestock rearing is a potential attraction factor for migrants to these communities.

Perceptions of the causes of climate change demonstrate the complex interplay of environmental, socioeconomic, and cultural factors that shape local understandings of this global phenomenon. The belief in the act of God as a cause reflects cultural and religious interpretations of natural events in most communities, while perceptions of greenhouse gas emissions and deforestation highlight awareness of anthropogenic contributions to climate change and the role of ecosystem degradation in exacerbating the impacts of climate change. Most communities perceive demographic shifts and therefore see population growth as a cause of climate change. This underscores the importance of addressing population pressure in climate change mitigation and adaptation efforts.

Leadership in environmental interventions often involves various actors, including government agencies, community leaders, politicians, nongovernmental organisations (NGOs), and religious bodies. Government agencies are perceived as major players in addressing environmental and climate-induced migration issues in all communities. Community leaders are also highlighted as major players in leading intervention discussions on environmental and climate challenges posed by migration. While previous research underscores the importance of stakeholder engagement and participatory approaches in addressing environmental and climate challenges, such approaches should be extended to discussions and interventions regarding climate and environment-induced migration.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The findings of this study offer insights into how environmental and climatic factors influence migration decisions in Nigeria. Although existing theories attempt to address various migration-related issues on a global scale, it is necessary to determine the extent to which changing environments and climate influence decisions to migrate. It is crucial to gain insight into the relationship between migration dynamics and the environment to develop effective policies and strategies to manage migration-related issues at origin and destination points. Thus, this study examines the extent to which environmental factors contribute to migration decisions in Nigeria using quantitative and qualitative data.

The findings of this study revealed an upward and statistically significant increase in air temperature at the local government areas (LGAs) of all the communities of origin (Kano Municipal, Kwali, Warri South-West, and Brass) between 1993 and 2022. In contrast, a significant decrease in precipitation was observed in the coastal communities of Warri South-West and Brass LGAs (at the 5 percent level). The focus group discussed the significant increase in temperature to urban growth, deforestation, and environmental degradation, which have resulted in adverse health impacts, particularly malaria, affecting the most vulnerable community members. Despite the lack of significant changes in precipitation levels, stakeholders identified an increase in the severity of flooding events, which may be linked to inadequate drainage systems and flawed urban planning. Furthermore, the livelihoods of coastal communities are significantly affected by rising sea levels. Furthermore, there was a notable decline in the ecological health of the migration origins at Kano Municipal, Kwali, and Warri South-West between 2003 and 2022, whereas the change was not statistically significant at Brass. The principal environmental climatic events affecting households in coastal communities of migration origins (Warri South-West and Brass) were sea level rise and flooding. Floods particularly affected the communities of Zango and Wako (of Kano Municipal and Kwali LGAs, respectively). Although drought affected a notable proportion of households in Zango, these environmental factors did not significantly affect households in Central (of Kwali LGA).

The search for job opportunities was identified as the major factor influencing migration decisions in Nigeria, followed by business and trading opportunities. It can be argued that socioeconomic factors are the primary motivating factors behind migration in Nigeria. This conclusion was supported by the participants of the organised FGDs conducted in the various communities. The environment/climate was identified as the third most significant factor influencing migration. The major climate-related factors influencing migration included persistent drought, inadequate rainfall, and water scarcity. Conversely, favourable weather and adequate rainfall were the primary climate-related factors that prompted migration.

Migration was perceived to be of utmost benefit to migrants, with the majority achieving their migration goals. These included access to greater opportunities, enhanced security, improved financial circumstances, and new skill acquisition. This affirms the socioeconomic benefits of migration while migrants enjoy some security at their destinations. There were notable discrepancies in the advantages of in-migration for the receiving communities. The benefits identified in several communities included economic prosperity, improved security, increased agricultural productivity, cheap labour from migrants and improved business for local products. However, in-migration has produced several significant challenges in various communities, with competition for jobs being the most notable among them. Other notable challenges included concerns about insecurity and the pressure on agricultural lands. The influx of migrants into urban areas has resulted in accelerated growth and subsequent land degradation in the communities that have received migrants. Considering these challenges, there is an urgent need to implement interventions and facilitate discourse on environmental and climate-induced migration in Nigeria. Most respondents identified government agencies and representatives as the most suitable leadership options for interventions addressing environmental and climate-induced migration. Other notable mentions included community leaders and politicians.

5.2 Recommendations

Based on the major findings and conclusions of this study, the following recommendations are recommended:

5.2.1 Recommendations for policy improvement

The empirical findings of this study are of great importance for developing innovative, locally based, and community-specific policies and strategies concerning the climate and environment-induced migration while enhancing existing policies. This will help organisations such as the International Organisation for Migration (IOM) and the Department of Climate Change of Nigeria's Federal Ministry of Environment develop policy frameworks and approaches to improve environmental management, climate change, and migration. The formulation and implementation of these policies will involve various stakeholders, including government agencies, civil society organisations, the private sector, community heads, NGOs, religious leaders and migrants themselves. The engagement of these policymakers and stakeholders enhances the need for targeted intervention and increases the efficiency of effective management strategies. The capacities of local institutions and community societies can also be developed to respond to environmental/climate-related migration challenges and establish a robust monitoring and evaluation framework to assess the effectiveness of these interventions. Moreover, IOM may organise seminars, online meetings, and forums to spread the word about research findings and successful intervention strategies. At the same time, key performance indicators (KPIs) can be used to keep track of progress and suggest areas for improvement.

Furthermore, establishing effective cooperation systems between communities and states can facilitate safe and orderly migration processes while optimising benefits and minimising challenges for destination communities. Collaborative efforts between the Federal Ministry of Environment, National Emergency Management Agency (NEMA), National Orientation Agency (NOA), Nigerian Meteorological Agency (NiMet), and Nigerian Environmental Society (NES) are crucial in creating public awareness campaigns to educate the public about the climate and environment-induced migration dynamics. This can be achieved through social media, electronic and print media, and community town hall meetings to reach diverse audiences.

Moreover, the legal frameworks overseen by the Federal Ministry of Labour and Employment and the Federal Ministry of Interior facilitate the socio-economic integration of migrant households in destination areas while protecting the rights of vulnerable migrant and non-migrant households. Migration management strategies can be developed based on indigenous knowledge, with feedback provided via participatory techniques such as community mapping, FGDs, and participatory rural appraisal.

To adequately address climate and environment-induced migration in Nigeria, more cohesive policy integration, stronger institutional coordination, and dedicated support are necessary. By prioritising the needs of vulnerable populations and fostering collaborative initiatives, Nigeria can more effectively address the growing migration pressures resulting from environmental factors. The establishment of adequate policy frameworks should be taken as a matter of urgent national interest to set up responsible and well-managed migration policies (SDG 10.7), make cities and human settlements inclusive, safe, resilient and sustainable (SDG 11), take urgent action to combat climate change and its impacts (SDG 13) and protect, restore and promote the conservation and sustainable use of terrestrial ecosystems (SDG 15).

5.2.2 Recommendations for performance improvement

This study focused on environmental and climatic events that affect households and their roles in influencing migration decisions from one location to another. The positive and negative effects on destination communities highlight the need for an all-inclusive assessment and enhancement of existing management strategies. NiMet and NEMA provide early warning alerts and response systems for heatwaves, floods, and droughts. However, these systems must be improved by ensuring prompt dissemination of information to vulnerable communities. The Federal Ministry of Agriculture, by implementing well-organised agricultural extension programmes, can provide training and technical resources for farmers on how to use drought-resistant crops, efficient water usage techniques, climate-smart farming practices, and sustainable land management. In addition, the Ministry of Housing and Urban Development may establish initiatives to implement adequate urban planning systems, drought-resistant water supply systems, and robust housing structures. Such measures will facilitate prompt action and reduce the incidence of environmental- and climate-related displacement and migration.

Due to the limited amount of available data, there is a need to invest in advanced data collection technologies, such as GIS, remote sensing, and mobile surveys, to gather accurate and up-to-date reliable data on migration patterns influenced by the environment and climatic impacts and create an extensive dataset. This innovation can be overseen through collaborative efforts between IOM, the National Centre for Remote Sensing (NCRS), and the Ministry of Environment. There is a need to develop research and development initiatives focused on environmental management, climate adaptation, and migration through grants and partnerships with academic institutions. In addition, promoting community-based capacity building on climate resilience and environmental conservation can foster awareness and resilience among various communities.

Due to the limited availability of data, there is a need to invest in advanced data collection technologies, such as GIS, remote sensing, and mobile surveys, to gather accurate and up-to-date, reliable data on migration patterns influenced by the environment and climatic impacts. This will enable the creation of a broad database. This innovation can be overseen through collaborative efforts between IOM, the National Centre for Remote Sensing (NCRS), and the Ministry of Environment. There is a need to establish research and development initiatives focused on environmental management, climate adaptation, and migration. This can be achieved through the allocation of grants and the formation of partnerships with academic institutions. Furthermore, it is necessary to implement community-based educational programmes that promote climate resilience and environmental conservation. The Ministry of Education at the federal and state levels can integrate climate change education into school curricula to foster awareness and resilience among future generations.

5.2.3 Suggestions for further research

Given the findings on the influence of climate and environment on internal migration in Nigeria, it is necessary to build on this research to enhance understanding and inform future policy and practice. This study establishes a foundation for future research by identifying key areas that require further investigation. These include studies of migration responses to slow-onset events (e.g., sea-level rise, land degradation) compared to rapid-onset events (frequent flash floods). The development of early warning systems based on the nature of events, as well as the formulation of adequate adaptation strategies and planning needs for each type of event, will be enhanced through this research.

Predictive models can be developed to predict migration patterns under different climate change scenarios. These models are based on environmental, climate, socioeconomic, and demographic variables. Meanwhile, additional research is required to examine the impact of climate and environment-induced migration on vulnerable groups, including children and the elderly, with a particular focus on the unique challenges faced by women and girls. Lastly, this study recommends interdisciplinary research studies that would integrate climate and environmental science, social sciences, economics, public health, and other relevant fields to understand the multifaceted nature of climate and environment-induced migration.

5.3 Contributions to Knowledge

This study revealed a significant increase in temperature at the migration origins in Kano Municipal, Kwali, and sea level rise in coastal communities of Warri South-West and Brass ($p < 0.05$). The study provided empirical evidence of a paradox: despite the established environmental and climatic changes, there was a notable reluctance to migrate. While perceptions of migration drivers were consistent across the communities ($H = 8.108, p = 0.423$), socioeconomic factors, particularly the pursuit of job opportunities (35%) and business/trading prospects (29%), were identified as the major drivers of migration. Climate and environmental factors were cited by 11% of the migrants, with persistent drought (32%) and inadequate rainfall (27%) being the major climatic drivers. Destination communities in Fagge, Kano Municipal, Gwagwalada, and Kwali faced significant variations in challenges due to migration ($H = 41.729$, $p < 0.05$). These challenges were competition for jobs (43.7%), insecurity (23.2%), pressure on agricultural lands (11.7%), pressure on environmental resources (10.7%), land degradation (7.6%), and pressure on land for development (3.4%). Furthermore, there was a significant variation among communities regarding who should be responsible for leading interventions related to climate and environment-induced migration ($H = 37.327$, $p < 0.05$). This study implies the complex interplay between climate and socioeconomic drivers, with climate acting as a critical stressor. Therefore, a holistic policy framework is essential to address these drivers of migration in origin communities and the pressures on destination communities in Nigeria.

REFERENCES

Abatan, A. A., Abiodun, B. J., Lawal, K. A., & Gutowski, W. J. (2016). Trends in extreme temperature over Nigeria from percentile-based threshold indices. *International Journal of Climatology*, *36*(6), 2527–2540. https://doi.org/10.1002/joc.4510

Abbass, K., Qasim, M. Z., Song, H., Murshed, M., Mahmood, H., & Younis, I. (2022). A review of the global climate change impacts, adaptation, and sustainable mitigation measures. *Environmental Science and Pollution Research*, *29*(28), 42539–42559. https://doi.org/10.1007/s11356-022-19718-6

Abolga, D. A. (2022). *Migration and settlement: Exploring what drives rural-urban displacement in Kumasi, Ghana* [Unpublished Master's Thesis, Norwegian University of Life Sciences, Ås]. https://nmbu.brage.unit.no/nmbu-xmlui/handle/11250/3042298

Adaawen, S., Rademacher-Schulz, C., Schraven, B., & Segadlo, N. (2019). Drought, migration, and conflict in sub-Saharan Africa: What are the links and policy options? *Current Directions in Water Scarcity Research*, *2*, 15–31.

Adedeji, O., Olusola, A., James, G., Shaba, H. A., Orimoloye, I. R., Singh, S. K., & Adelabu, S. (2020). Early warning systems development for agricultural drought assessment in Nigeria. *Environmental Monitoring and Assessment*, *192*(12), 798. https://doi.org/10.1007/s10661-020-08730-3

Adedokun, O. A., & Karzanova, I. V. (2019). Impact of migration on the economy of Nigeria: Recent Trends. *Вестник НГУЭУ*, *2*, 204–211.

Adenle, A. A., Eckert, S., Adedeji, O. I., Ellison, D., & Speranza, C. I. (2020). Human-induced land degradation dominance in the Nigerian Guinea Savannah between 2003 – 2018. *Remote Sensing Applications: Society and Environment*, *19*(July), 100360. https://doi.org/10.1016/j.rsase.2020.100360

Adetoro, O. I. O., Iyaomolere, M., & Salami, A. (2022). Coastal Flood Prone Communities and Sustainability. In S. Eslamian & F. Eslamian (Eds.), *Disaster Risk Reduction for Resilience* (pp. 357–391). Springer International Publishing. https://doi.org/10.1007/978-3-030-99063-3_15

Adger, W. N., Boyd, E., Fábos, A., Fransen, S., Jolivet, D., Neville, G., De Campos, R. S., & Vijge, M. J. (2019). Migration transforms the conditions for the achievement of the Sustainable Development Goals. *The Lancet Planetary Health*, *3*(11), e440–e442.

Adikwu, V. O., Edache, J. J., Iji, M. E., & Ogar, E. N. (2021). Emotional Abuse and Mental Health of Women in Abusive Marriage in Communities in Gwagwalada, Federal Capital Territory, Nigeria. *Mattawang: Jurnal Pengabdian Masyarakat*, *2*(1), 36–45.

Adofu, I., & Alhassan, A. (2018). Insecurity and economic development in Nigeria. *Journal of Economics and Sustainable Development*, *9*(18), 101–112.

Afuye, G. A., Kalumba, A. M., Ishola, K. A., & Orimoloye, I. R. (2022). Long-term dynamics and response to climate change of different vegetation types using GIMMS NDVI3g data over amathole district in South Africa. *Atmosphere*, *13*(4), 620.

Agwu, P., Okoye, U., Ekoh, P., Chukwu, N., Onalu, C., Igwe, I., Onuh, P., Amadi, G., & Nche, G. (2020). A systematic review of drivers and interventions against sex work migration in Edo State, Nigeria. *International Journal of Sociology and Social Policy*, *40*(7/8), 733–764.

Ahmed, M. N. Q., Givens, J. E., & Arredondo, A. (2024). The links between climate change and migration: A review of South Asian experiences. *SN Social Sciences*, *4*(3), 64. https://doi.org/10.1007/s43545-024-00864-2

Ajao, A. I., Jegede, O. O., & Ayoola, M. A. (2020). Diurnal and seasonal variability of sensible and latent heat fluxes at an agricultural site in Ile-Ife, southwest Nigeria. *Theoretical and Applied Climatology*, *139*(3–4), 1237–1246. https://doi.org/10.1007/s00704-019-03043-z

Akanle, O., & Ola-Lawson, O. D. (2022). International Migration, Diaspora Investments and Development in Nigeria. In *Migration in West Africa: IMISCOE Regional Reader* (pp. 153–167). Springer International Publishing Cham. https://library.oapen.org/bitstream/handle/20.500.12657/57331/1/978-3-030-97322-3.pdf#page=152

Akinbami, C. A. O. (2021). Migration and climate change impacts on rural entrepreneurs in Nigeria: A gender perspective. *Sustainability*, *13*(16), 8882.

Akinyemi, D. F., Ayanlade, O. S., Nwaezeigwe, J. O., & Ayanlade, A. (2020). A Comparison of the Accuracy of Multi-satellite Precipitation Estimation and Ground Meteorological Records Over Southwestern Nigeria. *Remote Sensing in Earth Systems Sciences*, *3*(1–2), 1–12. https://doi.org/10.1007/s41976-019-00029-3

Albrecht, T. R., Crootof, A., & Scott, C. A. (2018). The Water-Energy-Food Nexus: A systematic review of methods for nexus assessment. *Environmental Research Letters*, *13*(4), 043002.

Almulhim, A. I., Alverio, G. N., Sharifi, A., Shaw, R., Huq, S., Mahmud, M. J., Ahmad, S., & Abubakar, I. R. (2024). Climate-induced migration in the Global South: An in depth analysis. *Npj Climate Action*, *3*(1), 47.

Amosi, N., & Anyah, R. O. (2024). Trends of precipitation and temperature extremes over Malawi and Mozambique during the recent decades from models and observations. *Theoretical and Applied Climatology*, *155*(2), 783–804. https://doi.org/10.1007/s00704-023-04659-y

Araya-León, M. J., Guasch, R., Estévez, A. T., & Peña, J. (2023). Interaction between the interior built environment and the human being. An integrative review in relation to perception, health, and well-being. *Theoretical Issues in Ergonomics Science*, *24*(6), 698–728. https://doi.org/10.1080/1463922X.2022.2134940

Asuk, S. A., Offiong, E. E., Ifebueme, N. M., & Akpaso, E. O. (2018). Species composition and diversity of mangrove swamp forest in southern Nigeria. *International Journal of Avian & Wildlife Biology*, *3*(2), 159–164.

Atedhor, G. O., & Atedhor, C. N. (2024). Contexts of sustainable development risk in climate change and anthropogenic-induced bushfire in Nigeria. *Scientific African*, e02271.

Aturamu, O. A., Thompson, O. A., & Akintuyi, B. O. (2021). Forecasting the effect of climate variability on yam yield in rainforest and Guinea Savannah agro-ecological zone of Nigeria. *Journal of Global Agriculture and Ecology*, *11*(4), 1–12.

Aweda, E. D., Okhimamhe, A. A., Obateru, R. O., Schürmann, A., Teucher, M., & Conrad, C. (2024). Assessing the Impacts of Migration on Land Degradation in the Savannah Region of Nigeria. *Sustainability*, *16*(18), 8157.

Awolala, D., Mutemi, J., Adefisan, E., Antwi-Agyei, P., Taylor, A., Muita, R., Bosire, E., Mutai, B., & Nkiaka, E. (2023). Economic value and latent demand for agricultural drought forecast: Emerging market for weather and climate information in Central-Southern Nigeria. *Climate Risk Management*, *39*, 100478.

Ayeku, P. O. (2022). Climate Change and Anthropogenic Impacts on the Ecosystem of the Transgressive Mud Coastal Region of Bight of Benin, Nigeria. In *Vegetation Dynamics, Changing Ecosystems and Human Responsibility*. IntechOpen. https://www.intechopen.com/chapters/82808

Ayeni, O., & Kambizi, L. (2013). The interrelation of biodiversity dynamics, ecosystem processes and abiotic factors: A review. *African Journal of Basic & Applied Sciences*, *5*(1), 01–07.

Azare, I. M., Abdullahi, M. S., Adebayo, A. A., Dantata, I. J., & Duala, T. (2020). Deforestation, desert encroachment, climate change and agricultural production in the Sudano-Sahelian Region of Nigeria. *Journal of Applied Sciences and Environmental Management*, *24*(1), 127–132.

Babaniyi, G. G., Akor, U. J., & Adebomi, J. I. (2024). Legislation and Programs Supporting Envronmental Protection. In S. A. Aransiola, B. R. Babaniyi, A. B. Aransiola, & N. R. Maddela (Eds.), *Prospects for Soil Regeneration and Its Impact on Environmental Protection* (pp. 3–14). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-53270-2_1

Bekere, J., Senbeta, F., & Gelaw, A. (2023). Socioeconomic Drivers of Land Use and Land Cover Change in Western Ethiopia. *International Journal of Forestry Research*, *2023*, 1–19. https://doi.org/10.1155/2023/8831715

Benabou, A., Moukrim, S., Laaribya, S., Aafi, A., Chkhichekh, A., El Maadidi, T., & El Aboudi, A. (2022). Mapping ecosystem services of forest stands: Case study of Maamora, Morocco. *Geography, Environment, Sustainability*, *15*(1), 141–149.

Benson, A. (2020). Social and environmental drivers of climate change vulnerability in the Niger Delta region, Nigeria. *European Journal of Environment and Earth Sciences*, *1*(5). https://ej-geo.org/index.php/ejgeo/article/view/69

Bettini, G., & Gioli, G. (2016). Waltz with development: Insights on the developmentalization of climate-induced migration. *Migration and Development*, *5*(2), 171–189. https://doi.org/10.1080/21632324.2015.1096143

Betts, R. A., Alfieri, L., Bradshaw, C., Caesar, J., Feyen, L., Friedlingstein, P., Gohar, L., Koutroulis, A., Lewis, K., Morfopoulos, C., Papadimitriou, L., Richardson, K. J., Tsanis, I., & Wyser, K. (2018). Changes in climate extremes, fresh water availability and vulnerability to food insecurity projected at 1.5°C and 2°C global warming with a higher-resolution global climate model. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *376*(2119), 20160452. https://doi.org/10.1098/rsta.2016.0452

Borderon, M., Best, K. B., Bailey, K., Hopping, D. L., Dove, M., & Cervantes de Blois, C. L. (2021). The risks of invisibilization of populations and places in environment-migration research. *Humanities and Social Sciences Communications*, *8*(1). https://www.nature.com/articles/s41599-021-00999-0

Brettell, C. B., & Hollifield, J. F. (2022). Introduction: Migration theory: Talking across disciplines. In *Migration theory* (pp. 1–43). Routledge. https://www.taylorfrancis.com/chapters/edit/10.4324/9781003121015-1/introduction-caroline-brettell-james-hollifield

Brüning, L., & Piguet, E. (2018). Changements environnementaux et migration en Afrique de l'Ouest. Une revue des études de cas. *Belgeo*, *1*. https://doi.org/10.4000/belgeo.28836

Buschle, C., Reiter, H., & Bethmann, A. (2022). The qualitative pretest interview for questionnaire development: Outline of programme and practice. *Quality & Quantity*, *56*(2), 823–842. https://doi.org/10.1007/s11135-021-01156-0

Butu, A. W., & Emeribe, C. N. (2019). Spatial patterns of climatic variability and water budget over Sudan Savannah Region of Nigeria. *African Journal of Environmental Science and Technology*, *13*(12), 465–481.

Carling, J. (2002). Migration in the age of involuntary immobility: Theoretical reflections and Cape Verdean experiences. *Journal of Ethnic and Migration Studies*, *28*(1), 5–42. https://doi.org/10.1080/13691830120103912

Carter, I. (2017). *Human behavior in the social environment: A social systems approach*. Routledge. https://www.taylorfrancis.com/books/mono/10.4324/9780203789629/human-behavior-social-environment-irl-carter

Castelli, F. (2018). Drivers of migration: Why do people move? *Journal of Travel Medicine*, *25*(1), tay040. https://doi.org/10.1093/jtm/tay040

Cattaneo, C., & Peri, G. (2016). The migration response to increasing temperatures. *Journal of Development Economics*, *122*, 127–146.

Cazenave, A., & Moreira, L. (2022). Contemporary sea-level changes from global to local scales: A review. *Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *478*(2261), 20220049. https://doi.org/10.1098/rspa.2022.0049

Ceola, S., Mård, J., & Di Baldassarre, G. (2023). Drought and Human Mobility in Africa. *Earth's Future*, *11*(12), e2023EF003510. https://doi.org/10.1029/2023EF003510

Chakraborty, I., & Maity, P. (2020). Science of the Total Environment COVID-19 outbreak: Migration , effects on society , global environment and prevention. *Science of the Total Environment*, *728*, 138882. https://doi.org/10.1016/j.scitotenv.2020.138882

Chan, A. K. W., Cheung, L. T. O., Chong, E. K., Lee, M. Y. K., & Wong, M. Y. H. (2022). Hong Kong's new wave of migration: Socio-political factors of individuals' intention to emigrate. *Comparative Migration Studies*, *10*(1), 49. https://doi.org/10.1186/s40878-022-00323-y

Chanysheva, A., Kopp, P., Romasheva, N., & Nikulina, A. (2021). Migration attractiveness is a factor in developing the Russian arctic mineral resource potential. *Resources*, *10*(6), 65.

Chen, J., & Mueller, V. (2018). Coastal climate change, soil salinity and human migration in Bangladesh. *Nature Climate Change*, *8*(11), 981–985.

Clark, W. A. (2020). *Human migration*. https://researchrepository.wvu.edu/rri-web-book/15/

Clement, A. R. (2013). Vulnerability of fisheries livelihood in the coastal area of the Niger delta region of Nigeria. *World Journal of Fish and Marine Sciences*, *5*(2), 152–158.

Coelho, M. T. P., Barreto, E., Rangel, T. F., Diniz-Filho, J. A. F., Wüest, R. O., Bach, W., Skeels, A., McFadden, I. R., Roberts, D. W., & Pellissier, L. (2023). The geography of climate and the global patterns of species diversity. *Nature*, *622*(7983), 537–544.

Cook, B. I., Smerdon, J. E., Cook, E. R., Williams, A. P., Anchukaitis, K. J., Mankin, J. S., Allen, K., Andreu-Hayles, L., Ault, T. R., & Belmecheri, S. (2022). Megadroughts in the Common Era and the Anthropocene. *Nature Reviews Earth & Environment*, *3*(11), 741–757.

Cummings, C., Pacitto, J., Lauro, D., & Foresti, M. (2022). *Why people move: Understanding the drivers and trends of migration to Europe*. ODI. https://assets.publishing.service.gov.uk/media/5a803fe440f0b6230269266c/understanding-drivers-migration-Europe.pdf

Czaika, M., & Reinprecht, C. (2022). Migration drivers: Why do people migrate. *Introduction to Migration Studies: An Interactive Guide to the Literatures on Migration and Diversity*, 49–82.

Daoust, G., & Selby, J. (2024). Climate change and migration: A review and new framework for analysis. *WIREs Climate Change*, e886. https://doi.org/10.1002/wcc.886

Datti, A. D., Zeng, G., Tarnavsky, E., Cornforth, R., Pappenberger, F., Abdullahi, B. A., & Onyejuruwa, A. (2024). Evaluation of Satellite-Based Rainfall Estimates against Rain Gauge Observations across Agro-Climatic Zones of Nigeria, West Africa. *Remote Sensing*, *16*(10), 1755.

Dawa, S. Y., Tan, M. L., Samat, N., Roy, R., & Zhang, F. (2024). Evaluation of five gridded precipitation products for estimating precipitation and drought over Yobe, Nigeria. *Water Supply*, *24*(6), 2039–2054.

Dawi, T. B., Yoila, A. I., Kayode, D. C., Lucky, A. U., Shero, I. A., Alhaji, Y. A., ... & Ogbodo, U. O. (2017). Optimizing fertilizer use within the context of integrated soil fertility management in Nigeria. In *Fertilizer use optimization in sub-Saharan Africa* (pp. 148-163). GB: CABI.

De Haas, H. (2021). A theory of migration: The aspirations-capabilities framework. *Comparative Migration Studies*, *9*(1), 8. https://doi.org/10.1186/s40878-020-00210-4

de Sherbinin, A., Grace, K., McDermid, S., van der Geest, K., Puma, M. J., & Bell, A. (2022). Migration theory in climate mobility research. *Frontiers in Climate*, *4*, 882343.

Debray, A., Ruyssen, I., & Schewel, K. (2023). The Aspiration to Stay: A Global Analysis. *International Migration Review*, 01979183231216087. https://doi.org/10.1177/01979183231216087

Descroix, L., Luxereau, A., Lambert, L. A., Ruë, O., Diedhiou, A., Diongue-Niang, A., Dia, A. H., Gangneron, F., Manga, S. P., & Diedhiou, A. B. B. (2024). An Interdisciplinary Approach to Understand the Resilience of Agrosystems in the Sahel and West Africa. *Sustainability*, *16*(13), 5555.

Di Cristo, N., & Akwei, C. (2023). 'Wish to Dream' Fulfilment: The Motivations for Onward Migration. *Journal of International Migration and Integration*, *24*(3), 989–1016. https://doi.org/10.1007/s12134-022-00988-5

Dike, V. N., Lin, Z.-H., & Ibe, C. C. (2020). Intensification of summer rainfall extremes over Nigeria during recent decades. *Atmosphere*, *11*(10), 1084.

Domeisen, D. I., Eltahir, E. A., Fischer, E. M., Knutti, R., Perkins-Kirkpatrick, S. E., Schär, C., Seneviratne, S. I., Weisheimer, A., & Wernli, H. (2023). Prediction and projection of heatwaves. *Nature Reviews Earth & Environment*, *4*(1), 36–50.

Duijndam, S. J., Botzen, W. J. W., Hagedoorn, L. C., & Aerts, J. C. J. H. (2022). Anticipating sea-level rise and human migration: A review of empirical evidence and avenues for future research. *WIREs Climate Change*, *13*(1), e747. https://doi.org/10.1002/wcc.747

Eduvie, M. O., & Oseke, I. F. (2021). Cumulative Impacts of Climate Change Variability Around the Goronyo Dam in the Iullemmeden Basin, Northwest Nigeria. In S. Diop, P. Scheren, & A. Niang (Eds.), *Climate Change and Water Resources in Africa* (pp. 171–192). Springer International Publishing. https://doi.org/10.1007/978-3-030-61225-2_8

Ekoh, S. S., Teron, L., & Ajibade, I. (2023). Climate change and coastal megacities: Adapting through mobility. *Global Environmental Change*, *80*, 102666.

Ekoh, S. S., Teron, L., Ajibade, I., & Kristiansen, S. (2022). Flood risk perceptions and future migration intentions of Lagos residents. *International Journal of Disaster Risk Reduction*, *83*, 103399.

Eleanya, K., Agbeja, B. O., & Ijeomah, H. M. (2015). Socio-economic importance of mangrove forests in Akassa Island of Niger Delta, Nigeria. *PAT Journal*, *11*, 1–11.

Elekwachi, W., Phil-eze, P. O., Etuk, E. A., Wizor, C. H., & Onyishi, C. J. (2021). *Spatiotemporal Characteristics of Wetlands Ecosystem in the Niger Delta Region*. 244–264. https://doi.org/10.4236/gep.2021.912015

Elias, P., & Omojola, A. (2015). Case study: The challenges of climate change for Lagos, Nigeria. *Current Opinion in Environmental Sustainability*, *13*, 74–78.

Elisha, O. D., & Felix, M. J. (2021). Destruction of coastal ecosystems and the vicious cycle of poverty in Niger Delta Region. *Journal of Global Agriculture and Ecology*, *11*(2), 7–24.

Eludoyin, A. O., Omotoso, I., Eludoyin, O. M., & Popoola, K. S. (2019). Remote Sensing Technology for Evaluation of Variations in Land Surface Temperature, and Case Study Analysis from Southwest Nigeria. In K. Koutsopoulos, R. De Miguel González, & K. Donert (Eds.), *Geospatial Challenges in the 21st Century* (pp. 151–170). Springer International Publishing. https://doi.org/10.1007/978-3-030-04750-4_8

Eneji, A. G., & Agri, E. M. (2020). Insecurity, conflict and socioeconomic development in Nigeria. *Social Science Journal*, *8*, 1–19.

Erfurt, M., Glaser, R., & Blauhut, V. (2019). Changing impacts and societal responses to drought in southwestern Germany since 1800. *Regional Environmental Change*, *19*(8), 2311–2323. https://doi.org/10.1007/s10113-019-01522-7

Etikan, I., Musa, S. A., & Alkassim, R. S. (2016). Comparison of convenience sampling and purposive sampling. *American Journal of Theoretical and Applied Statistics*, *5*(1), 1–4.

Ettekal, A. V., & Mahoney, J. L. (2017). The SAGE encyclopedia of out-of-school learning. *Ecological Systems Theory*, 230–241.

Ezeudu, T. S., & Tukur, B. (2024). Examining the Effects of High Poverty and Unemployment on Rural Urban Migration in Nigeria and its Consequences on Urban Resources and Rural Decline. *Journal of Clinical and Applied Vaccines and Immunology*. https://www.vaccinesimmunojournal.com/apdf/jcavi-aid1012.pdf

Fan, Z., Li, W., Cai, X., Li, H., Wei, C., Zhang, Q., Deb, K., & Goodman, E. (2019). Push and pull search for solving constrained multi-objective optimization problems. *Swarm and Evolutionary Computation*, *44*, 665–679.

Faret, L., Téllez, M. E. A., & Rodríguez-Tapia, L. H. (2021). Migration Management and Changes in Mobility Patterns in the North and Central American Region. *Journal on Migration and Human Security*, *9*(2), 63–79. https://doi.org/10.1177/23315024211008096

Fekadu, K. (2014). The paradox in environmental determinism and possibilism: A literature review. *Journal of Geography and Regional Planning*, *7*(7), 132–139.

Ferris, E. (2020). Research on climate change and migration where are we and where are we going? *Migration Studies*, *8*(4), 612–625.

Fischer, P. A., Martin, R., & Straubhaar, T. (2021). Should I stay or should I go? In *International migration, immobility and development* (pp. 49–90). Routledge. https://www.taylorfrancis.com/chapters/edit/10.4324/9781003136125-3/stay-go-peter-fischer-reiner-martin-thomas-straubhaar

Fuwape, I. A., & Ogunjo, S. T. (2018). *Modeling of raining season onset and cessation of tropical rainfall for climate change adaptation in Agriculture* (No. arXiv:1811.09677). arXiv. http://arxiv.org/abs/1811.09677

Gbode, I. E., Babalola, T. E., Diro, G. T., & Intsiful, J. D. (2023). Assessment of ERA5 and ERA-Interim in Reproducing Mean and Extreme Climates over West Africa. *Advances in Atmospheric Sciences*, *40*(4), 570–586. https://doi.org/10.1007/s00376-022-2161-8

Ghosh, R. C., & Orchiston, C. (2022). A systematic review of climate migration research: Gaps in existing literature. *SN Social Sciences*, *2*(5), 47. https://doi.org/10.1007/s43545-022-00341-8

Gower, J., & Barale, V. (2024). The Rising Concern for Sea Level Rise: Altimeter Record and Geo-Engineering Debate. *Remote Sensing*, *16*(2), 262.

Gupta, V., Jain, M. K., Singh, P. K., & Singh, V. (2020). An assessment of global satellite-based precipitation datasets in capturing precipitation extremes: A comparison with observed precipitation dataset in India. *International Journal of Climatology*, *40*(8), 3667–3688.

Gutman, G., Skakun, S., & Gitelson, A. (2021). Revisiting the use of red and near-infrared reflectances in vegetation studies and numerical climate models. *Science of Remote Sensing*, *4*, 100025.

Haasnoot, M., Winter, G., Brown, S., Dawson, R. J., Ward, P. J., & Eilander, D. (2021). Long-term sea-level rise necessitates a commitment to adaptation: A first order assessment. *Climate Risk Management*, *34*, 100355.

Haile, G. G., Tang, Q., Li, W., Liu, X., & Zhang, X. (2020). Drought: Progress in broadening its understanding. *WIREs Water*, *7*(2), e1407. https://doi.org/10.1002/wat2.1407

Halliru, S. L., El-Ladan, Y. I., Abdulrashid, L., & Hashidu, U. S. (2024). Perception and Impact of Climate Change on Human Migration: A Study in Northern Nigeria. In M. Mishra, A. J. De Lucena, & B. Maharaj (Eds.), *Climate Change and Regional Socio-Economic Systems in the Global South* (pp. 213–232). Springer Nature Singapore. https://doi.org/10.1007/978-981-97-3870-0_12

Hamlington, B. D., Gardner, A. S., Ivins, E., Lenaerts, J. T. M., Reager, J. T., Trossman, D. S., Zaron, E. D., Adhikari, S., Arendt, A., Aschwanden, A., Beckley, B. D., Bekaert, D. P. S., Blewitt, G., Caron, L., Chambers, D. P., Chandanpurkar, H. A., Christianson, K., Csatho, B., Cullather, R. I., … Willis, M. J. (2020). Understanding of Contemporary Regional Sea-Level Change and the Implications for the Future. *Reviews of Geophysics*, *58*(3), e2019RG000672. https://doi.org/10.1029/2019RG000672

Hansen, J., Sato, M., Hearty, P., Ruedy, R., Kelley, M., Masson-Delmotte, V., Russell, G., Tselioudis, G., Cao, J., & Rignot, E. (2020). Ice Melt, Sea Level Rise and Superstorms: Evidence from Paleoclimate Data, Climate Modeling, and Modern Observations Implies that 2 C Global Warming Above the Preindustrial Level Would Be Dangerous. *Earth and Its Atmosphere. Vide Leaf, Hyderabad. Https://Doi. Org/10.37247/EA*, *1*, 13.

Hedeker, D. (2003). A mixed-effects multinomial logistic regression model. *Statistics in Medicine*, *22*(9), 1433–1446. https://doi.org/10.1002/sim.1522

Hermans, K., & McLeman, R. (2021). Climate change, drought, land degradation and migration: Exploring the linkages. *Current Opinion in Environmental Sustainability*, *50*, 236–244.

Hermans, K., Wiederkehr, C., Groth, J., & Sakdapolrak, P. (2023). What we know and do not know about reciprocal pathways of environmental change and migration: Lessons from Ethiopia. *Ecology and Society*, *28*(3). https://www.econstor.eu/handle/10419/276224

Hernández-Blanco, M., Costanza, R., Chen, H., deGroot, D., Jarvis, D., Kubiszewski, I., Montoya, J., Sangha, K., Stoeckl, N., Turner, K., & Van 'T Hoff, V. (2022). Ecosystem health, ecosystem services, and the well-being of humans and the rest of nature. *Global Change Biology*, *28*(17), 5027–5040. https://doi.org/10.1111/gcb.16281

Hersbach, H., Bell, B., Berrisford, P., Hirahara, S., Horányi, A., Muñoz-Sabater, J., Nicolas, J., Peubey, C., Radu, R., Schepers, D., Simmons, A., Soci, C., Abdalla, S., Abellan, X., Balsamo, G., Bechtold, P., Biavati, G., Bidlot, J., Bonavita, M., … Thépaut, J. (2020). The ERA5 global reanalysis. *Quarterly Journal of the Royal Meteorological Society*, *146*(730), 1999–2049. https://doi.org/10.1002/qj.3803

Hirsch, R. M., & Slack, J. R. (1984). A Nonparametric Trend Test for Seasonal Data With Serial Dependence. *Water Resources Research*, *20*(6), 727–732. https://doi.org/10.1029/WR020i006p00727

Hoffmann, R., Dimitrova, A., Muttarak, R., Crespo Cuaresma, J., & Peisker, J. (2020). A meta-analysis of country-level studies on environmental change and migration. *Nature Climate Change*, *10*(10), 904–912.

Hoffmann, R., Šedová, B., & Vinke, K. (2021). Improving the evidence base: A methodological review of the quantitative climate migration literature. *Global Environmental Change*, *71*, 102367.

Hollander, M., Wolfe, D. A., & Chicken, E. (2013). *Nonparametric statistical methods*. John Wiley & Sons. https://books.google.com/books?hl=en&lr=&id=Y5s3AgAAQBAJ&oi=fnd&pg=PP10&dq=Hollander+M,+Wolfe+DA,+Chicken+E+(2013)+Nonparametric+statistical+methods.+John+Wiley+%26+Sons,+Hoboken,+New+Jersey&ots=a-h0j1blxS&sig=ZKWPqYYLB0C4gD60d_mqUyYMhZA

Hunter, L. M., & Nawrotzki, R. (2016). Migration and the Environment. In M. J. White (Ed.), *International Handbook of Migration and Population Distribution* (Vol. 6, pp. 465–484). Springer Netherlands. https://doi.org/10.1007/978-94-017-7282-2_21

Ibrahim, D. A. (2017). *Application of Geospatial Technology in Assessing the Impact of Urbanization on Vegetation Degradation in Kuje Area Council, Abuja Nigeria* [Master's Thesis, University of Abuja (Nigeria)]. https://search.proquest.com/openview/626a818916662a580bcfd419cf919cff/1?pq-origsite=gscholar&cbl=2026366&diss=y&casa_token=RWEaleuVY9sAAAAA:cA0o76QFXqUjKvM2-VyjFINTaRXmvGtVz8N8GAnZJecr2JIhNRDoOQW_Fj5ylJ-vZDRIpbQmvn0

Idrees, M. O., Omar, D. M., Babalola, A., Ahmadu, H. A., Yusuf, A., & Lawal, F. O. (2022). Urban land use land cover mapping in tropical savannah using Landsat-8 derived normalized difference vegetation index (NDVI) threshold. *South African Journal of Geomatics*, *11*(1). https://www.ajol.info/index.php/sajg/article/view/231204

Igbawua, T., Gbanger, M. H., & Ujoh, F. (2022). Suitability analysis for yam production in Nigeria using satellite and observation data. *Journal of the Nigerian Society of Physical Sciences*, 883–883.

Igwe, D. O. (2020). Climate Variation-Induced Migration, Land Conflicts, and Security Situation in Nigeria. *The Age of Human Rights Journal*, *14*, 63–75.

Ikhuoso, O. A., Adegbeye, M. J., Elghandour, M. M. Y., Mellado, M., Al-Dobaib, S. N., & Salem, A. Z. M. (2020). Climate change and agriculture: The competition for limited resources amidst crop farmers-livestock herding conflict in Nigeria-A review. *Journal of Cleaner Production*, *272*, 123104.

Islam, M. R. (2018). Climate Change, Natural Disasters and Socioeconomic Livelihood Vulnerabilities: Migration Decision Among the Char Land People in Bangladesh. *Social Indicators Research*, *136*(2), 575–593. https://doi.org/10.1007/s11205-017-1563-y

Johnston, T. (2017). Environmental Determinism. In D. Richardson, N. Castree, M. F. Goodchild, A. Kobayashi, W. Liu, & R. A. Marston (Eds.), *International Encyclopedia of Geography* (1st ed., pp. 1–3). Wiley. https://doi.org/10.1002/9781118786352.wbieg0353

Jónsson, G. (2010). *The environmental factor in migration dynamics-a review of African case studies*. University of Oxford. https://ora.ox.ac.uk/objects/uuid:cece31bd-0118-4481-acc2-e9ca05f9a763

Kabir, M., Habiba, U. E., Khan, W., Shah, A., Rahim, S., Patricio, R., Ali, L., & Shafiq, M. (2023). Climate change due to increasing concentration of carbon dioxide and its impacts on environment in 21st century; a mini review. *Journal of King Saud University-Science*, *35*(5), 102693.

Kamta, F. N., Schilling, J., & Scheffran, J. (2020). Insecurity, resource scarcity, and migration to camps of internally displaced persons in northeast Nigeria. *Sustainability*, *12*(17), 6830.

Karpestam, P., & Andersson, F. N. (2013). Economic perspectives on migration. In *Routledge International Handbook of Migration Studies* (pp. 29–44). Routledge. https://www.taylorfrancis.com/chapters/edit/10.4324/9780203863299-10/economic-perspectives-migration-peter-karpestam-fredrik-andersson

Kebede, T. A., Hailu, B. T., & Suryabhagavan, K. V. (2022). Evaluation of spectral built-up indices for impervious surface extraction using Sentinel-2A MSI imageries: A case of Addis Ababa city, Ethiopia. *Environmental Challenges*, *8*, 100568.

Kendall, M. G. (1946). *Contributions to the Study of Oscillatory Time-series*. CUP Archive. https://books.google.com/books?hl=en&lr=&id=vXE3AAAAIAAJ&oi=fnd&pg=PP12&dq=Kendall,+1946+&ots=qwPD8Ydgtm&sig=MB2u9dA6cfQ6KVmppOc_zYfVzK4

Khojasteh, D., Haghani, M., Nicholls, R. J., Moftakhari, H., Sadat-Noori, M., Mach, K. J., Fagherazzi, S., Vafeidis, A. T., Barbier, E., & Shamsipour, A. (2023). The evolving landscape of sea-level rise science from 1990 to 2021. *Communications Earth & Environment*, *4*(1), 257.

Kogan, F. N. (1997). Global drought watch from space. *Bulletin of the American Meteorological Society*, *78*(4), 621–636.

Kperegbeyi, J. I., & Ogboi, E. (2015). Effects of Atlantic Ocean Encroachment on Limited Arable Land in Escravos Metropolis, Delta State, Nigeria. *Open Access Library Journal*, *2*(8), 1–7.

Kumar, K. P., Babu, K. R., Anusha, B. N., & Rajasekhar, M. (2022). Geo-environmental monitoring and assessment of land degradation and desertification in the semi-arid regions using Landsat 8 OLI/TIRS, LST, and NDVI approach. *Environmental Challenges*, *8*, 100578.

Kumi, N., Adeliyi, T. E., Asante, V. A., Abiodun, B. J., & Lamptey, B. L. (2023). Impact of rainfall onset date on crops yield in Ghana. *Frontiers in Sustainable Food Systems*, *7*, 1176385.

Kumpikaitė -Valiūnienė, V., Liubinienė, V., Žičkutė, I., Duobienė, J., Mockaitis, A. I., & Mihi-Ramirez, A. (2021). *Migration Culture: A Comparative Perspective*. Springer International Publishing. https://doi.org/10.1007/978-3-030-73014-7

Lagakos, D. (2020). Urban-rural gaps in the developing world: Does internal migration offer opportunities? *Journal of Economic Perspectives*, *34*(3), 174–192.

Lavers, D. A., Hersbach, H., Rodwell, M. J., & Simmons, A. (2024). An improved estimate of daily precipitation from the ERA5 reanalysis. *Atmospheric Science Letters*, *25*(3), e1200. https://doi.org/10.1002/asl.1200

Lee, E. S. (1966). A theory of migration. *Demography*, *3*(1), 47–57. https://doi.org/10.2307/2060063

Legeais, J. F., Meyssignac, B., Faugère, Y., Guerou, A., Ablain, M., Pujol, M. I., & Dibarboure, G. (2021). Copernicus Sea Level Space Observations: A Basis for Assessing Mitigation and Developing Adaptation Strategies to Sea Level Rise. *Frontiers in Marine Science*, *8*, 704721.

Lenshie, N. E., Ojeh, V. N., Oruonye, E. D., Ezeibe, C., Ajaero, C., Nzeadibe, T. C., Celestine, U. U., & Osadebe, N. (2022). Geopolitics of climate change-induced conflict and population displacement in West Africa. *Local Environment*, *27*(3), 287–308. https://doi.org/10.1080/13549839.2022.2040461

Li, Q., & Samimi, C. (2022). Sub-Saharan Africa’s international migration constrains its sustainable development under climate change. *Sustainability Science*, *17*(5), 1873–1897. https://doi.org/10.1007/s11625-022-01116-z

Liu, F., Zhao, Y., Muhammad, R., Liu, X., & Chen, M. (2020). Impervious surface expansion: A key indicator for environment and urban agglomeration—A case study of Guangdong-Hong Kong-Macao greater bay area by using Landsat data. *Journal of Sensors*, *2020*, 1–21.

López-Bermeo, C., Montoya, R. D., Caro-Lopera, F. J., & Díaz-García, J. A. (2022). Validation of the accuracy of the CHIRPS precipitation dataset at representing climate variability in a tropical mountainous region of South America. *Physics and Chemistry of the Earth, Parts A/B/C*, *127*, 103184.

Lu, T., Zhang, W., Abel, C., Horion, S., Brandt, M., Huang, K., & Fensholt, R. (2024). Changes in vegetation-water response in the Sahel-Sudan during recent decades. *Journal of Hydrology: Regional Studies*, *52*, 101672.

Macaulay, B. M. (2014). Land degradation in Northern Nigeria: The impacts and implications of human-related and climatic factors. *African Journal of Environmental Science and Technology*, *8*(5), 267-273.

Madu, I. A., & Nwankwo, C. F. (2021). Spatial pattern of climate change and farmer–herder conflict vulnerabilities in Nigeria. *GeoJournal*, *86*(6), 2691–2707. https://doi.org/10.1007/s10708-020-10223-2

Madziga, I. I. (2021). Impact of climate change on livestock productivity: A review. *Nigerian Journal of Animal Production*, *48*(4), 149–164.

Mafiana, C. F., Jayeola, O. A., & Iduseri, E. O. (2022). Impact of environmental degradation on biodiversity conservation in Nigeria. *Zoologist (The)*, *20*(1), 41–50.

Mallick, J., Talukdar, S., Alsubih, M., Salam, R., Ahmed, M., Kahla, N. B., & Shamimuzzaman, Md. (2021). Analysing the trend of rainfall in Asir region of Saudi Arabia using the family of Mann-Kendall tests, innovative trend analysis, and detrended fluctuation analysis. *Theoretical and Applied Climatology*, *143*(1–2), 823–841. https://doi.org/10.1007/s00704-020-03448-1

Mann, H. B. (1945). Nonparametric tests against trend. *Econometrica: Journal of the Econometric Society*, 245–259.

McIntyre, J. (2014). Mobility in the Hausa language. *Canadian Journal of African Studies / Revue Canadienne Des Études Africaines*, *48*(1), 101–117. https://doi.org/10.1080/00083968.2014.922274

McKee, T. B., Doesken, N. J., & Kleist, J. (1993). The relationship of drought frequency and duration to time scales. *Proceedings of the 8th Conference on Applied Climatology*, *17*(22), 179–183. https://climate.colostate.edu/pdfs/relationshipofdroughtfrequency.pdf

Mehdizadeh, M., Nordfjaern, T., & Klöckner, C. A. (2022). A systematic review of the agent-based modelling/simulation paradigm in mobility transition. *Technological Forecasting and Social Change*, *184*, 122011.

Melet, A., Buontempo, C., Mattiuzzi, M., Salamon, P., Bahurel, P., Breyiannis, G., & Voukouvalas, E. (2021). Frontiers | European Copernicus Services to Inform on Sea-Level Rise Adaptation: Current Status and Perspectives. *Frontiers in Marine Science*, *8*, 703425.

Michael, T. O. (2024). A qualitative exploration of the influence of climate change on migration of women in the riverine area of Bayelsa state, Nigeria. *Social Sciences*, *13*(2), 89.

Missirian, A., & Schlenker, W. (2017). Asylum applications respond to temperature fluctuations. *Science*, *358*(6370), 1610–1614. https://doi.org/10.1126/science.aao0432

Mohamed, M.-A., & Abdul-Talib, A.-N. (2020). Push–pull factors influencing international return migration intentions: A systematic literature review. *Journal of Enterprising Communities: People and Places in the Global Economy*, *14*(2), 231–246.

Mohammed, M. U., Hassan, N. I., & Badamasi, M. M. (2019). In search of missing links: Urbanisation and climate change in Kano Metropolis, Nigeria. *International Journal of Urban Sustainable Development*, *11*(3), 309–318. https://doi.org/10.1080/19463138.2019.1603154

Mokwenye, I. I. (2020). Estimation of Flood Magnitude and Frequency of Escravos Bay in Delta State Nigeria using Log Pearson Type (iii) Distribution. *FUPRE Journal of Scientific and Industrial Research (FJSIR)*, *4*(1), 50–59.

Moussa-Kourouma, J., Eze, E., Negash, E., Phiri, D., Vinya, R., Girma, A., & Zenebe, A. (2021). Assessing the spatio-temporal variability of NDVI and VCI as indices of crops productivity in Ethiopia: A remote sensing approach. *Geomatics, Natural Hazards and Risk*, *12*(1), 2880–2903. https://doi.org/10.1080/19475705.2021.1976849

Muhammad, A., Egbetokun, A., & Memon, M. H. (2015). Human capital and economic growth: the role of governance. *The Pakistan Development Review*, 529-548.

Muhammad, D., & Abdulraman, D. (2022). The Role of Kano Industrial Economies, Urban Settlement and Migration in the West African Integration. *International Journal of Humanities, Literature and Art Research*. https://mediterraneanpublications.com/mejhlar/article/view/87

Müller, F., Burkhard, B., Kandziora, M., Schimming, C., & Windhorst, W. (2020). Ecological indicators: Ecosystem health. In *Managing biological and ecological systems* (pp. 207–227). CRC Press. https://www.taylorfrancis.com/chapters/edit/10.1201/9780429346170-23/ecological-indicators-ecosystem-health-felix-m%C3%BCller-benjamin-burkhard-marion-kandziora-claus-schimming-wilhelm-windhorst

Nagelkerke, N. J. (1991). A note on a general definition of the coefficient of determination. *Biometrika*, *78*(3), 691–692.

Naz, U., & Saleem, M. S. (2024). Climate-Induced Vulnerabilities: Conflict and Migration Patterns in the Sahel Region of Africa. *Pakistan Languages and Humanities Review*, *8*(2), 295–311.

Ndayiragije, J. M., & Li, F. (2022). Effectiveness of drought indices in the assessment of different types of droughts, managing and mitigating their effects. *Climate*, *10*(9), 125.

Neumann, K., & Hermans, F. (2017). What drives human migration in Sahelian Countries? A meta-analysis. *Population, Space and Place*, *23*(1), e1962.

Ngene, B. U., & Obianigwe, N. (2018). Nigerian rain gauge station optimization and national development: The importance of head count. *IOP Conference Series: Materials Science and Engineering*, *413*(1), 012022. https://iopscience.iop.org/article/10.1088/1757-899X/413/1/012022/meta

Ngoungue-Langue, C. G., Lavaysse, C., Vrac, M., & Flamant, C. (2023). Heat wave monitoring over West African cities: Uncertainties, characterization and recent trends. *Natural Hazards and Earth System Sciences*, *23*(4), 1313–1333.

Nji, T. M., & Balgah, R. A. (2019). Determinants of coping strategies to floods and droughts in multiple geo-ecological zones. *Natural Hazards-Risk, Exposure, Response, and Resilience*, 163.

Numbere, A. O., & Maduike, E. M. (2022). The Impact of Unsustainable Exploitation of Forest and Aquatic Resources of the Niger Delta, Nigeria. In S. Chibueze Izah (Ed.), *Biodiversity in Africa: Potentials, Threats and Conservation* (Vol. 29, pp. 239–265). Springer Nature Singapore. https://doi.org/10.1007/978-981-19-3326-4_9

Nyadzi, E., Bessah, E., & Kranjac-Berisavljevic, G. (2021). Taking Stock of Climate Change Induced Sea Level Rise across the West African Coast. *Environmental Claims Journal*, *33*(1), 77–90. https://doi.org/10.1080/10406026.2020.1847873

Nzegbule, E., & Obiajunwa, U. (2024). Barriers and Enablers for Effective Adoption of Nature-Based Solutions (NbS) in Climate Change Mitigation and Adaptation in Nigeria. In W. Leal Filho, G. J. Nagy, & D. Y. Ayal (Eds.), *Handbook of Nature-Based Solutions to Mitigation and Adaptation to Climate Change* (pp. 1–20). Springer International Publishing. https://doi.org/10.1007/978-3-030-98067-2_90-1

Obateru, R. O., Okhimamhe, A. A., Fashae, O. A., Aweda, E., Dragovich, D., & Conrad, C. (2024). Community-based assessment of the dynamics of urban landscape characteristics and ecosystem services in the rainforest and guinea savanna ecoregions of Nigeria. *Journal of Environmental Management*, *360*, 121191.

Odekunle, T. O., Adesina, F. A., Gbode, I. E., Adeyefa, A. O., & Ajadi, S. O. (2024). Variabilities and trends in the onset, peak, and retreat of Intertropical Discontinuity (ITD) annual migrations over West Africa between 1979 and 2020. *Climate Dynamics*. https://doi.org/10.1007/s00382-024-07270-7

Odoh, S. I., & Chilaka, F. C. (2012). Climate Change and Conflict in Nigeria: A Theoretical and Empirical Examination of the Worsening Incidence of Conflict between Fulani Herdsmen and Farmers in. *Oman Chapter of Arabian Journal of Business and Management Review*, *2*(1), 110–124. https://doi.org/10.12816/0002246

Ofuoku, A. U., & Okompu, D. (2022). Migration among Farmers in Delta State, Nigeria: Is it a Climate Change Adaptation Strategy? *Journal of Agriculture and Environment for International Development (JAEID)*, *116*(1), 5–28.

Ogbu, K. N., Hounguè, N. R., Gbode, I. E., & Tischbein, B. (2020). Performance evaluation of satellite-based rainfall products over Nigeria. *Climate*, *8*(10), 103.

Ogunrayi, O. A., Akinseye, F. M., Goldberg, V., & Bernhofer, C. (2016). Descriptive analysis of rainfall and temperature trends over Akure, Nigeria. *Journal of Geography and Regional Planning*, *9*(11), 195–202.

Ogunrinde, A. T., Enaboifo, M. A., Olotu, Y., Pham, Q. B., & Tayo, A. B. (2021). Characterization of drought using four drought indices under climate change in the Sahel region of Nigeria: 1981–2015. *Theoretical and Applied Climatology*, *143*(1–2), 843–860. https://doi.org/10.1007/s00704-020-03453-4

Ojekunle, Z. O., Oyebamiji, F. F., Olatunde, K. A., Ojekunle, V. O., & Sangowusi, O. R. (2014). *Global climatic change in Nigeria: A reality or mirage*. https://ir.unilag.edu.ng/handle/123456789/5787

Oke, O. E., Uyanga, V. A., Iyasere, O. S., Oke, F. O., Majekodunmi, B. C., Logunleko, M. O., Abiona, J. A., Nwosu, E. U., Abioja, M. O., & Daramola, J. O. (2021). Environmental stress and livestock productivity in hot-humid tropics: Alleviation and future perspectives. *Journal of Thermal Biology*, *100*, 103077.

Okeleye, S. O., Okhimamhe, A. A., Sanfo, S., & Fürst, C. (2023). Impacts of Land Use and Land Cover Changes on Migration and Food Security of North Central Region, Nigeria. *Land*, *12*(5), 1012.

Olagunju, T. E. (2015). Drought, desertification and the Nigerian environment: A review. *Journal of Ecology and the Natural Environment*, *7*(7), 196–209.

Olagunju, T. E., Adewoye, S. O., Adewoye, A. O., & Opasola, O. A. (2021). Climate Change Impacts on Environment: Human Displacement and Social Conflicts in Nigeria. *IOP Conference Series: Earth and Environmental Science*, *655*(1). https://doi.org/10.1088/1755-1315/655/1/012072

Olayide, O. E., & Alabi, T. (2018). Between rainfall and food poverty: Assessing vulnerability to climate change in an agricultural economy. *Journal of Cleaner Production*, *198*, 1–10.

Ologeh, I. O., Akarakiri, J. B., & Sobanke, V. O. (2021). Assessment of Climate Change-Induced Migration of Crop Farmers in Northern Nigeria. In W. Leal Filho, J. Luetz, & D. Ayal (Eds.), *Handbook of Climate Change Management* (pp. 1–17). Springer International Publishing. https://doi.org/10.1007/978-3-030-22759-3_231-1

Ologunorisa, T. E., Obioma, O., & Eludoyin, A. O. (2022). Urban flood event and associated damage in the Benue valley, Nigeria. *Natural Hazards*, *111*(1), 261–282. https://doi.org/10.1007/s11069-021-05052-6

Olomola, A. S., & Nwafor, M. (2018). *Nigeria agriculture sector performance review.* International Institute of Tropical Agriculture (IITA): Ibadan, Nigeria, 3. https://www.researchgate.net/profile/Manson-Nwafor/publication/327666294_NIGERIA_AGRICULTURE_SECTOR_PERFORMANCE_REVIEW_2017/links/5b9ccd93a6fdccd3cb57c292/NIGERIA-AGRICULTURE-SECTOR-PERFORMANCE-REVIEW-2017.pdf

Oloruntade, A. J., Mohammad, T. A., & Aimrun, W. (2017). Rainfall Trends in the Niger-South Basin, Nigeria, 1948-2008. *Pertanika Journal of Science & Technology*, *25*(2). http://psasir.upm.edu.my/id/eprint/52519/1/08%20JST%20Vol%2025%20%282%29%20Apr%202017_JST-0632-2016R1_pg479-496.pdf

Oloyede, M. O., Williams, A. B., Ode, G. O., & Benson, N. U. (2022). Coastal vulnerability assessment: A case study of the Nigerian coastline. *Sustainability*, *14*(4), 2097.

Olufemi, O. S., Joshua, M. I., & Abraham Salamatu, E. (2020). Assessment of temperature variability effect on rice production in Nasarawa State, Nigeria. *International Journal of Environment and Climate Change*, *10*(8), 91–100.

Olujobi, O. J. (2024). Nigeria's Climate Change Act 2021: A pathway to net-zero carbon emission, energy security and sustainability. *Environmental Science and Pollution Research*, *31*(25), 36834–36848. https://doi.org/10.1007/s11356-024-33347-1

Onyena, A. P., & Sam, K. (2020). A review of the threat of oil exploitation to mangrove ecosystem: Insights from Niger Delta, Nigeria. *Global Ecology and Conservation*, *22*, e00961.

Orimoloye, I. R., Belle, J. A., Orimoloye, Y. M., Olusola, A. O., & Ololade, O. O. (2022). Drought: A common environmental disaster. *Atmosphere*, *13*(1), 111.

Orimoloye, I. R., Ololade, O. O., & Belle, J. A. (2021). Satellite-based application in drought disaster assessment using terra MOD13Q1 data across free state province, South Africa. *Journal of Environmental Management*, *285*, 112112.

Osabohien, R., Osabuohien, E., & Urhie, E. (2018). Food security, institutional framework and technology: Examining the nexus in Nigeria using ARDL approach. *Current Nutrition & Food Science*, *14*(2), 154–163.

Ostertagova, E., Ostertag, O., & Kováč, J. (2014). Methodology and application of the Kruskal-Wallis test. *Applied Mechanics and Materials*, *611*, 115–120.

Oyeniyi, B. A. (2013). Internal migration in Nigeria: A positive contribution to human development. *ACP Observatory on Migration International Organization for Migration*. https://www.academia.edu/download/31067762/Internal_Migration_Nigeria.pdf

Palinkas, L. A., Horwitz, S. M., Green, C. A., Wisdom, J. P., Duan, N., & Hoagwood, K. (2015). Purposeful Sampling for Qualitative Data Collection and Analysis in Mixed Method Implementation Research. *Administration and Policy in Mental Health and Mental Health Services Research*, *42*(5), 533–544. https://doi.org/10.1007/s10488-013-0528-y

Pan, S. C., & Carpenter, S. K. (2023). Prequestioning and Pretesting Effects: A Review of Empirical Research, Theoretical Perspectives, and Implications for Educational Practice. *Educational Psychology Review*, *35*(4), 97. https://doi.org/10.1007/s10648-023-09814-5

Pate, A., Riley, R. D., Collins, G. S., Van Smeden, M., Van Calster, B., Ensor, J., & Martin, G. P. (2023). Minimum sample size for developing a multivariable prediction model using multinomial logistic regression. *Statistical Methods in Medical Research*, *32*(3), 555–571. https://doi.org/10.1177/09622802231151220

Peng, L., & Jia, R. (2023). Exploring the interplay of the physical environment and organizational climate in innovation. *Sustainability*, *15*(20), 15013.

Perumal, N. (2018). "The place where I live is where I belong": Community perspectives on climate change and climate-related migration in the Pacific island nation of Vanuatu. *Island Studies Journal*, *13*(1), 45–64.

Piguet, E. (2022). Linking climate change, environmental degradation, and migration: An update after 10 years. *WIREs Climate Change*, *13*(1), e746. https://doi.org/10.1002/wcc.746

Pourzand, F., & Noy, I. (2022). Catastrophic droughts and their economic consequences. In *Oxford Research Encyclopedia of Environmental Science*. https://oxfordre.com/environmentalscience/display/10.1093/acrefore/9780199389414.001.0001/acrefore-9780199389414-e-689

Prince, A. I., Nzechie, O., Obiorah, J., Ehi, O. E., & Idakwoji, A. A. (2023). Analyzing the critical impact of climate change on agriculture and food security in Nigeria. *Int. J. Agric. Earth Sci.*, *9*, 42023.

Qureshi, H. U., Shah, S. M. H., & Teo, F. Y. (2023). Trend assessment of changing climate patterns over the major agro-climatic zones of Sindh and Punjab. *Frontiers in Water*, *5*, 1194540.

Raimi, M. O., Vivien, O. T., & Oluwatoyin, O. A. (2021). Creating the healthiest nation: Climate change and environmental health impacts in Nigeria: A narrative review. *Scholink Sustainability in Environment*, *6*(1), 62.

Rigaud, K. K., de Sherbinin, A., Jones, B., Abu-Ata, N. E., & Adamo, S. (2021). Groundswell Africa. *Groundswell Africa*. https://doi.org/10.1596/36448

Rigaud, K. K., de Sherbinin, A., Jones, B., Bergmann, J., Clement, V., Ober, K., Schewe, J., Adamo, S., McCusker, B., & Heuser, S. (2018). *Groundswell: Preparing for internal climate migration*. https://openknowledge.worldbank.org/handle/10986/29461;

Rivera, J. A., Hinrichs, S., & Marianetti, G. (2019). Using CHIRPS Dataset to Assess Wet and Dry Conditions along the Semiarid Central-Western Argentina. *Advances in Meteorology*, *2019*, 1–18. https://doi.org/10.1155/2019/8413964

Rosengärtner, S. K., De Sherbinin, A. M., & Stojanov, R. (2023). Supporting the agency of cities as climate migration destinations. *International Migration*, *61*(5), 98–115. https://doi.org/10.1111/imig.13024

Rosmilawati, I., & Sofyan, D. (2021). Push or Full Factors. *First Transnational Webinar on Adult and Continuing Education (TRACED 2020)*, 153–158. https://www.atlantis-press.com/proceedings/traced-20/125956339

Sa'adi, Z., Yusop, Z., Alias, N. E., Shiru, M. S., Muhammad, M. K. I., & Ramli, M. W. A. (2023). Application of CHIRPS dataset in the selection of rain-based indices for drought assessments in Johor River Basin, Malaysia. *Science of the Total Environment*, *892*, 164471.

Salakpi, E. E. K. (2022). *Forecasting vegetation condition in pastoral communities for disaster prevention* [Unpublished PhD Thesis, University of Sussex]. https://sussex.figshare.com/articles/thesis/Forecasting_vegetation_condition_in_pastoral_communities_for_disaster_prevention/23487011

Salami, W. A., Tayo-Badru, M. A., Adeofun, C. O., & Oguntoke, O. (2020). Effects of Urban Expansion on Vegetation Cover Loss in Lagos State, Nigeria. *African Journal of Science and Nature*, *10*, 146–163.

Sam, M. G., Nwaogazie, I. L., & Ikebude, C. (2022). Climate change and trend analysis of 24-hourly annual maximum series using Mann-Kendall and Sen slope methods for rainfall IDF modeling. *Internat. Jour. Environ. Climate Change*, *12*(3), 44–60.

Sanchi, I. D., Alhassan, Y. J., Manga, T. A., & Sabo, A. Y. (2024). Impact of Soaring Food Prices and Erratic rainfall on the 2024 Growing Season in Northern Nigeria: The way forward. *African Journal of Environment and Sustainable Development*, *2*(3), 1–15.

Seidu, A., Onel, G., & Moss, C. B. (2022). Do international remittances accelerate out-farm labor migration in developing countries? A dynamic panel time-series analysis. *Journal of Agribusiness in Developing and Emerging Economies*, *12*(1), 19–39.

Shah, J. N., Shah, J., & Shah, J. (2020). Quarantine, isolation and lockdown: In context of COVID-19. *Journal of Patan Academy of Health Sciences*, *7*(1), 48–57.

Shen, Z., Yong, B., Gourley, J. J., Qi, W., Lu, D., Liu, J., Ren, L., Hong, Y., & Zhang, J. (2020). Recent global performance of the Climate Hazards group Infrared Precipitation (CHIRP) with Stations (CHIRPS). *Journal of Hydrology*, *591*, 125284.

Shiru, M. S., Chung, E. S., Shahid, S., & Alias, N. (2020). GCM selection and temperature projection of Nigeria under different RCPs of the CMIP5 GCMS. *Theoretical and Applied Climatology*, *141*(3–4), 1611–1627. https://doi.org/10.1007/s00704-020-03274-5

Shiru, M. S., Shahid, S., Alias, N., & Chung, E. S. (2018). Trend analysis of droughts during crop growing seasons of Nigeria. *Sustainability*, *10*(3), 871.

Sim, J., & Waterfield, J. (2019). Focus group methodology: Some ethical challenges. *Quality & Quantity*, *53*(6), 3003–3022. https://doi.org/10.1007/s11135-019-00914-5

Simoncelli, S., Manzella, G. M. R., Storto, A., Pisano, A., Lipizer, M., Barth, A., Myroshnychenko, V., Boyer, T., Troupin, C., Coatanoan, C., Pititto, A., Schlitzer, R., Schaap, D. M. A., & Diggs, S. (2022). Chapter Four—A collaborative framework among data producers, managers, and users. *Ocean Science Data*, 197–280. https://doi.org/10.1016/B978-0-12-823427-3.00001-3

Simpson, N. B. (2022). Demographic and economic determinants of migration. *IZA World of Labor*. https://wol.iza.org/articles/demographic-and-economic-determinants-of-migration/long

Smirnov, O., Lahav, G., Orbell, J., Zhang, M., & Xiao, T. (2023). Climate Change, Drought, and Potential Environmental Migration Flows Under Different Policy Scenarios. *International Migration Review*, *57*(1), 36–67. https://doi.org/10.1177/01979183221079850

Sonali, P., & Paul, S. (2021). Spatio-temporal dependency of vegetation dynamics on climatic variables during 1982–2015 over India. *Advances in Space Research*, *68*(11), 4616–4635.

Stoler, J., Pearson, A. L., Rosinger, A. Y., Lee, A. E., Bombardi, R., Brewis, A., Keough, S. B., López-Carr, D., Shrader, C., Stauber, C. E., Stevenson, E. G. J., Sullivan, A., & Tutu, R. A. (2022). The role of water in environmental migration. *WIREs Water*, *9*(3), e1584. https://doi.org/10.1002/wat2.1584

Sultan, B., & Gaetani, M. (2016). Agriculture in West Africa in the twenty-first century: Climate change and impacts scenarios, and potential for adaptation. *Frontiers in Plant Science*, *7*(AUG2016), 1–20. https://doi.org/10.3389/fpls.2016.01262

Taherkhani, M., Vitousek, S., Barnard, P. L., Frazer, N., Anderson, T. R., & Fletcher, C. H. (2020). Sea-level rise exponentially increases coastal flood frequency. *Scientific Reports*, *10*(1), 1–17.

Taiwo, O., Addie, O., & Seun-Addie, K. (2023). A local government area based Covid-19 vulnerability analysis in Nigeria. *GeoJournal*, *88*(4), 4127–4141. https://doi.org/10.1007/s10708-023-10857-y

Tarfa, P. Y., Ayuba, H. K., Onyeneke, R. U., Idris, N., Nwajiuba, C. A., & Igberi, C. O. (2019). Climate change perception and adaptation in Nigeria's guinea savanna: Empirical evidence from farmers in Nasarawa State, Nigeria. *Applied Ecology & Environmental Research*, *17*(3). https://aloki.hu/pdf/1703_70857112.pdf

Teye, J. K. (2022). *Migration in West Africa: IMISCOE Regional Reader*. Springer International Publishing. https://doi.org/10.1007/978-3-030-97322-3

Teye, J. K., & Nikoi, E. G. (2022). Climate-induced migration in West Africa. In *Migration in West Africa: IMISCOE Regional Reader* (pp. 79–105). Springer International Publishing Cham. https://library.oapen.org/bitstream/handle/20.500.12657/57331/978-3-030-97322-3.pdf?sequence=1#page=82

Thorn, J. P. R., Nangolo, P., Biancardi, R. A., Shackleton, S., Marchant, R. A., Ajala, O., Delgado, G., Mfune, J. K. E., Cinderby, S., & Hejnowicz, A. P. (2023). Exploring the benefits and dis-benefits of climate migration as an adaptive strategy along the rural-peri-urban continuum in Namibia. *Regional Environmental Change*, *23*(1), 10. https://doi.org/10.1007/s10113-022-01973-5

Thornthwaite, C. W. (1948). An approach toward a rational classification of climate. *Geographical Review*, *38*(1), 55–94.

Timans, R., Wouters, P., & Heilbron, J. (2019). Mixed methods research: What it is and what it could be. *Theory and Society*, *48*(2), 193–216. https://doi.org/10.1007/s11186-019-09345-5

Toka, S. O. (2022). Change in land cover, rainfall and flood incidence in Etiâ€“Osa, Lagos, Nigeria. *South African Journal of Geomatics*, *11*(2). http://sajg.org.za/index.php/sajg/article/view/852

Toney, M. B., & Bailey, A. K. (2014). Migration, an overview. *Encyclopedia of Quality of Life and Well-Being Research*, *171*.

Uchegbulam, O., Ameloko, A. A., & Omo-Irabor, O. O. (2021). Effect of cloud cover on land use land cover dynamics using remotely sensed data of western Niger Delta, Nigeria. *Journal of Applied Sciences and Environmental Management*, *25*(5), 799–804.

Udo, R. K. (2023). *Geographical regions of Nigeria*. Univ of California Press. https://books.google.com/books?hl=en&lr=&id=F2HhEAAAQBAJ&oi=fnd&pg=PA18&dq=The+Guinea+Savanna+This+ecological+zone+is+home+to+25%25+of+the+Nigerian+population,+supports+three-quarters+of+the+cattle+population,+approximately+75%25+of+the+goat+and+sheep+population,+and+almost+all+the+donkey,+camel+and+horse+populations+found+within+the+country&ots=LHCOkbKGYy&sig=rmO6VQZ1zyKjlQ1PuOxfao0SRkM

Van Hear, N., Bakewell, O., & Long, K. (2020). Push-pull plus: Reconsidering the drivers of migration. In *Aspiration, Desire and the Drivers of Migration* (pp. 19–36). Routledge. https://www.taylorfrancis.com/chapters/edit/10.4324/9780429281181-1/push-pull-plus-reconsidering-drivers-migration-nicholas-van-hear-oliver-bakewell-katy-long

Vicente-Serrano, S. M., & Beguería, S. (2016). Comment on'Candidate distributions for climatological drought indices (SPI and SPEI)'by James H. Stagge et al. *International Journal of Climatology*, *36*(4). https://search.ebscohost.com/login.aspx?direct=true&profile=ehost&scope=site&authtype=crawler&jrnl=08998418&AN=113577061&h=42HGm4dXiUkVhsDDHc%2FE%2BG3S2lGyGZUY0LISq290BnV4%2FAJP5uhNO9nJlSywC31qwpSlTahY51guIq7xPxqQeQ%3D%3D&crl=c

Wahab, B., & Popoola, A. (2018). Climate-Induced Problems and Adaptation Strategies of Urban Farmers in Ibadan. *Ethiopian Journal of Environmental Studies & Management*, *11*(1). 88-97. https://www.researchgate.net/profile/Ayobami-Popoola-3/publication/323703368_CLIMATE-INDUCED_PROBLEMS_AND_ADAPTATION_STRATEGIES_OF_URBAN_FARMERS_IN_IBADAN/links/5aa6b991aca272326825efd6/CLIMATE-INDUCED-PROBLEMS-AND-ADAPTATION-STRATEGIES-OF-URBAN-FARMERS-IN-IBADAN.pdf

Wang, F., Harindintwali, J. D., Wei, K., Shan, Y., Mi, Z., Costello, M. J., Grunwald, S., Feng, Z., Wang, F., Guo, Y., Wu, X., Kumar, P., Kästner, M., Feng, X., Kang, S., Liu, Z., Fu, Y., Zhao, W., Ouyang, C., … Tiedje, J. M. (2023). Climate change: Strategies for mitigation and adaptation. *The Innovation Geoscience*, *1*(1), 100015. https://doi.org/10.59717/j.xinn-geo.2023.100015

Watmough, G., Agarwal, S., Singh, N., McNeill, G., Hornby, D., Igobwa, A., Odipo, V., Seth, S., Sovoe, S., & Johnston, R. (2024). *How can we produce a time series of country-level childhood wasting estimates, accounting for seasonality: Exploring the impact of* *survey timing?* University of Edinburgh Data for Children Collaborative. https://era.ed.ac.uk/handle/1842/41777

Weeraratne, B. (2022). Migration and economic remittances: Impact on development. In Triandafyllidou (Ed.), *Routledge Handbook of Immigration and Refugee Studies* (pp. 267–275). Routledge. https://doi.org/10.4324/9781003194316-32

Wiederkehr, C., Schröter, M., Adams, H., Seppelt, R., & Hermans, K. (2019). How does nature contribute to human mobility? A conceptual framework and qualitative analysis. *Ecology and Society*, *24*(4). https://library.wur.nl/WebQuery/wurpubs/560890

Wilkinson, E., Schipper, L., Simonet, C., & Kubik, Z. (2022). *Climate change, migration and the 2030 Agenda for Sustainable Development*. ODI. https://environmentalmigration.iom.int/sites/g/files/tmzbdl1411/files/documents/2023-11/11144.pdf. 10th January 2024.

Wolde, S. G., D'Odorico, P., & Rulli, M. C. (2023). Environmental drivers of human migration in Sub-Saharan Africa. *Global Sustainability*, *6*, e9.

Xu, L., & Famiglietti, J. S. (2023). Global patterns of water-driven human migration. *WIREs Water*, *10*(4), e1647. https://doi.org/10.1002/wat2.1647

Yamusa, A. M., & Abdulkadir, A. (2020). Rainfall and temperature trends in Samaru and Minjibir, Northern Guinea and Sudan Savannas of Nigeria. *Journal of Sustainable Agriculture and the Environment (JSAE)*, *18*(1), 255–265.

Yeleliere, E., Antwi-Agyei, P., & Guodaar, L. (2023). Farmers response to climate variability and change in rainfed farming systems: Insight from lived experiences of farmers. *Heliyon*, *9*(9). https://www.cell.com/heliyon/fulltext/S2405-8440(23)06864-0

Yengoh, G. T., Dent, D., Olsson, L., Tengberg, A. E., & Tucker, C. J. (2015). Applications of NDVI for Land Degradation Assessment. In G. T. Yengoh, D. Dent, L. Olsson, A. E. Tengberg, & C. J. Tucker Iii, *Use of the Normalized Difference Vegetation Index (NDVI) to Assess Land Degradation at Multiple Scales* (pp. 17–25). Springer International Publishing. https://doi.org/10.1007/978-3-319-24112-8_3

Zabbey, N., Giadom, F. D., & Babatunde, B. B. (2019). Nigerian coastal environments. In *World seas: An environmental evaluation* (pp. 835–854). Elsevier. https://www.sciencedirect.com/science/article/pii/B9780128050682000425

Zelinsky, W. (1971). The hypothesis of the mobility transition. *Geographical Review*, 219–249.

Zeng, L., Wardlow, B. D., Hu, S., Zhang, X., Zhou, G., Peng, G., Xiang, D., Wang, R., Meng, R., & Wu, W. (2021). A novel strategy to reconstruct NDVI time-series with high temporal resolution from MODIS multi-temporal composite products. *Remote Sensing*, *13*(7), 1397.

Zeng, W., Ding, X., Sun, W., & Mu, X. (2023). Improvement of satellite-based rainfall product CHIRPS in estimating rainfall erosivity on the Loess Plateau. *Land Degradation & Development*, *34*(15), 4517–4528. https://doi.org/10.1002/ldr.4790

Zheng, Y., Tang, L., & Wang, H. (2021). An improved approach for monitoring urban built-up areas by combining NPP-VIIRS nighttime light, NDVI, NDWI, and NDBI. *Journal of Cleaner Production*, *328*, 129488.

Zhu, Z., Qiu, S., He, B., & Deng, C. (2018). Cloud and cloud shadow detection for Landsat images: The fundamental basis for analyzing Landsat time series. *Remote Sensing Time Series Image Processing*, 3–23.

APPENDICES

Appendix A – Questionnaire for Household Respondents in the Study Communities on Climate and Environment-induced Migration in Nigeria

---

Dear Respondent,

My name is Emmanuel Aweda from the Federal University of Technology, Minna. I am conducting a research study titled **"EVALUATION OF CLIMATE AND ENVIRONMENT-INDUCED MIGRATION IN NIGERIA".** I am a research student working in your community and your participation in this study would provide useful information. The information you provide will be treated with the utmost confidentiality and anonymity. Kindly express your candid opinion which would serve as a source of vital information for this study. Thank you.

Ethical protocol/Informed consent:

[ ] Yes [ ] No

State

[ ] Kano [ ] Abuja [ ] Delta [ ] Bayelsa

Zone

[ ] Coastal [ ] Savannah [ ] Transitional [ ]

Name of Local Government Area

[ ] Fagge [ ] Kano Municipal [ ] Gwagwalada [ ] Kwali [ ] Warri South-West [ ] Brass

Name of Community

[ ] Sabon Gari West [ ] Sabon Gari East [ ] Tundun Nufawa [ ] Zango [ ] Wako

[ ] Central [ ] Tungamaje [ ] Zuba [ ] Odioma [ ] Twon [ ] Ogidigben [ ] Ugborodo

Segment

[ ] 1 [ ] 2 [ ] 3

Generated code: ______________________

House number:

In reference to segmentation numbering ______________________

Household number: ______________________________

Eligibility

[ ] Migrant [ ] Non-migrant

GPS Number/Code 1

latitude (x.y °)

longitude (x.y °)

altitude (m)

accuracy (m)

SECTION 1: MIGRATION STATU

OF RESPONDENT

1. Sex

[ ] Male [ ] Female

2. Age

[ ] Below 15 years [ ] 16 - 25 years [ ] 26 - 35 years [ ] 36 - 45 years [ ] 46 - 55 years

[ ] 56 - 65 years [ ] Above 65 years

3. Marital Status

[ ] Single [ ] Married [ ] Separated [ ] Divorced [ ] Widowed [ ] In-cohabitation

4. Highest level of education

[ ] None [ ] Koranic education [ ] Primary School [ ] Junior Secondary School

[ ] Senior Secondary School [ ] Technical School [ ] Vocational studies [ ] Tertiary

5. Size of Household

[ ] 1 [ ] 2 – 5 [ ] 6 – 9 [ ] 10 – 13 [ ] 14 – 17 [ ] 18 – 21 [ ] More than 21

6. Number of dependents living within your household

[ ] 1 [ ] 2 – 5 [ ] 6 – 9 [ ] 10 – 13 [ ] 14 – 17 [ ] 18 – 21 [ ] More than 21

7. Religious Affiliation

[ ] No Religion [ ] Islam [ ] Christianity [ ] Traditional

8. Current Employment Status

[ ] Employed [ ] Unemployed [ ] Student/apprentice [ ] Retired

9. In what economic activity(ies) are you engaged?

Tick all that apply

[ ] Farming [ ] Fishing [ ] Trading [ ] Manufacturing [ ] Service provision [ ] None

10. What is your annual income?

Amount in Naira (or you convert to dollar equivalent).

[ ] <N26,000 [ ] N26,001-52,000 [ ] N52,001-104,000 [ ] N104,001-156,000

[ ] N156,001-260,000 [ ] N260,001-415,000 [ ] N415,001-520,000 [ ] >N520,001

SECTION 2: MECHANISMS AND DRIVERS OF MIGRATION

AA: FOR MIGRANTS

11. Where was your place of origin before migrating to this current destination?

Indicate names of Community, Local Government, State.

____

12. Was this movement your first migration?

[ ] Yes [ ] No

13. Where did you next migrate to? In chronological order, list all areas migrated to

Indicate names of Community, Local Government, State.

____

14. What was your main source of livelihood activity at your most recent place of origin/last destination?

[ ] Farming [ ] Trading [ ] Manufacturing [ ] Service provision [ ] None

15. What are the main reasons why you left your most recent place of origin/last destination? *Tick all that apply*

[ ] Inadequate job opportunities [ ] Environmental/ Climate-related factors [ ] Socio-cultural ties [ ] Opportunities for trading [ ] Historical ties [ ] Unavailability of land [ ] Opportunity for quality education [ ] Insecurity [ ] Others

15b. Specify

____

16. Have you achieved the reasons for migrating to your current destination?

[ ] Achieved [ ] Likely to achieve [ ] Not likely to achieve [ ] Not achieved [ ] Still observing

17. Has your household been affected by any of the following climatic events

Tick all that apply

[ ] Flood [ ] Drought [ ] Sea Level Rise [ ] None

18. What environmental and climate change factors influenced you to migrate from your most recent place of origin/ last destination to the current destination?

Tick all that apply

[ ] Inadequate rainfall [ ] Persistent drought [ ] Land degradation [ ] Scarcity of water [ ] Rising sea level [ ] Floods [ ] Extreme temperature

18b. Specify ____

19. What specific environmental and climate factors attracted you to the present

destination? *Tick all that apply*

[ ] Adequate rainfall [ ] Fertile soils [ ] Good weather conditions [ ] Abundant natural pasture [ ] Other

20.To what extent do you agree or disagree that out-migration has been beneficial to you? [ ] Strongly agree [ ] Agree [ ] Neutral [ ] Disagree [ ] Strongly disagree

21. In what specific way(s) have you benefitted from out-migration from your most recent place of origin /last destination to the current destination? *Tick all that apply*

[ ] Financial enhancement [ ] Skills development [ ] Peace of mind/security

[ ] Land/environmental safety [ ] More opportunities [ ] New social network [ ] None

[ ] Other

21b. Specify ____

22. What benefits does your current destination community derive from in-migration? *Tick all that apply*

[ ] In-migrants do menial jobs [ ] Improved security [ ] Increased in agricultural production [ ] Social network [ ] Economic prosperity [ ] Availability of market for local products [ ] Increase in labour for agriculture [ ] None [ ] Other

22b. Specify ____

23.What challenges do your current destination community face from in-migration? *Tick all that apply*

[ ] Competition for jobs [ ] Insecurity [ ] Competition for agricultural land [ ] Pressure on available environmental resources [ ] Depletion of local resources [ ] Pressure on land for development [ ] Other

23b. Specify ____

BB: NON-MIGRANTS

24. Have you ever nurtured the intention to migrate? [ ] Yes [ ] No

25. Do you currently have any intention to migrate? [ ] Yes [ ] No

26. Where do you intend to migrate to?

Indicate names of Community, Local Government State

____

27. In order of sequence, kindly list the places you would want to migrate to from your location to the destination

____

28. State the reasons why you want to migrate *Tick all that apply*

[ ] Land degradation [ ] Persistent drought [ ] Inadequate rainfall [ ] Rising Sea Level [ ] Extreme Temperature [ ] Poor soils [ ] Inadequate farmlands [ ] Inadequate job opportunities [ ] Socio-cultural ties [ ] Search for better business opportunities [ ] Historical ties [ ] Opportunity for quality education [ ] Poor accommodation [ ] Insecurity [ ] Adventure [ ] Other

28b. Specify ____

29. Do you know of anyone who has migrated from this community before?

[ ] Yes [ ] No

30. What was the main destination of the people you know?

Indicate names of Community, Local Government State.

____

31. What do you think were the main reasons why they migrated?

Tick all that apply

[ ] Land degradation [ ] Inadequate job opportunities [ ] Persistent drought

[ ] Extreme Temperature [ ] Inadequate rainfall [ ] Poor Soil [ ] Inadequate farmlands

[ ] Scarcity of water [ ] Socio-cultural ties [ ] Search for better business opportunities

[ ] Historical ties [ ] Opportunity for quality education [ ] Poor accommodation

[ ] Insecurity [ ] Rising Sea Level [ ] Other

31b. Specify ____

32. Has your household been affected by any of the following climatic events

Tick all that apply

[ ] Flood [ ] Drought [ ] Sea Level Rise [ ] None

23. What benefits does your current destination community derive from in-migration?

Tick all that apply

[ ] In-migrants do menial jobs [ ] Improved security [ ] Increased in agricultural production [ ] Social network [ ] Economic prosperity [ ] Availability of market for local products [ ] Increase in labour for agriculture [ ] None [ ] Other

23b. Specify ____

34.What challenges do your current destination community face from in-migration?

Tick all that apply

[ ] Competition for jobs [ ] Insecurity [ ] Competition for agricultural land [ ] Pressure on available environmental resources [ ] Depletion of local resources [ ] Pressure on land for development [ ] Other

34b. Specify ____

SECTION 3: OTHER PERCEPTIONS ON ENVIRONMENT AND CLIMATE CHANGE ISSUES

35. What do you think causes climate change?

[ ] Population increase [ ] Act of God [ ] Cutting down trees [ ] Greenhouse gas emissions/Pollution [ ] Too many cars [ ] Changes in lifestyle [ ] Pressure on land use systems [ ] I don’t know [ ] Others

36. In your opinion which agency, organisation or individual do you think should lead discussions on climate and environment-induced migration?

[ ] The community leader [ ] Government [ ] Politicians [ ] Non-Governmental Organisations [ ] Religious bodies [ ] Others

36b. Specify ____

GPS Number/Code 2

____

latitude (x.y °)

____

longitude (x.y °)

____

altitude (m)

____

accuracy (m)

____

Any other comment

____

THANK YOU FOR COMPLETING THIS QUESTIONNAIRE!

Appendix B – Focus Group Discussion Guide

I. Issues on Migration

1. What were the main drivers of migration from your place of origin to that last destination?

2. What were the main attractions to that last destination?

3. What factors facilitated your migration from the place of origin to that last destination?

4. What were the main motive for migrating?

II. Knowledge on Climate Change and Impacts on Livelihoods and Migration Patterns

5. Have you ever heard about climate change or variability?

6. What are the signs or evidence that the climate is changing?

7. What factors are causing changes in the climate/environment?

8. What is your main livelihood activity and what are the impacts of climate change/changes on your main livelihood activity?

9. What challenges do you face in your livelihood activity at present?

10. How has climate change affected the livelihoods of people in this community?

11. Have these changes influenced your decision to migrate or stay in the area?

III. Community Perceptions on Migration

12. What challenges and benefits are associated with migration (in- migration or out-migration) in this community?

13. What are the socio-economic implications of environment-induced migration on the community?

14. What are the environmental implications of environment-induced migration on the community?

15. Any other information on the issues discussed.

Appendix C: Socio-Demographic Characteristics of Respondents

Variable		Kano Municipal LGA	Fagge LGA	Gwagwalada LGA	Kwali LGA	Warri South West LGA	Brass LGA
Gender	Male	165 (91.7 %)	147 (81.7 %)	77 (42.8 %)	144 (80.0)	76 (42.2 %)	87 (48.3 %)
	Female	15 (8.3 %)	33 (18.3 %)	103 (57.2 %)	36 (20.0 %)	104 (57.8 %)	93 (51.7 %)
Age	16 - 25 years	10 (5.6 %)	21 (11.7 %)	26 (14.4 %)	9 (5.0 %)	17 (9.4 %)	6 (3.3 %)
	26 - 35 years	27 (15.0 %)	41 (22.8 %)	48 (26.7 %)	59 (32.8 %)	58 (32.2 %)	35 (19.4 %)
	36 - 45 years	53 (29.4 %)	56 (31.1 %)	67 (37.2 %)	59 (32.8 %)	58 (32.2 %)	83 (46.1 %)
	46 - 55 years	64 (35.6 %)	49 (27.2 %)	29 (16.1 %)	39 (21.7 %)	43 (23.9 %)	38 (21.1 %)
	56 - 65 years	20 (11.1 %)	12 (6.7 %)	8 (4.4 %)	10 (5.6 %)	2 (1.1 %)	9 (5.0 %)
	Above 65 years	6 (3.3 %)	1 (0.6 %)	2 (1.1)	4 (2.2 %)	2 (1.1 %)	9 (5.0 %)
Marital Status	Single	22 (12.2 %)	57 (31.7 %)	31 (17.2 %)	35 (19.4 %)	41 (22.8 %)	31 (17.2 %)
	In Cohabitation	0 (0 %)	0 (0 %)	0 (0 %)	0 (0 %)	10 (5.6 %)	1(0.6 %)
	Married	157 (87.2 %)	117 (65.0 %)	148 (82.2 %)	144 (80 %)	113 (62.8 %)	105 (58.3 %)
	Separated	0 (0 %)	0 (0 %)	0 (0 %)	0 (0 %)	2 (1.1 %)	22 (12.2 %)
	Divorced	1 (0.6 %)	4 (2.2 %)	0 (0 %)	1 (0.6 %)	6 (3.3 %)	7 (3.9 %)

	Widowed	0 (0 %)	2 (1.1 %)	1 (0.6 %)	0 (0 %)	8 (4.4 %)	14 (7.8 %)
Highest Education Level	No Formal Education	38 (21.1 %)	16 (8.9 %)	12 (6.6 %)	48 (26.6 %)	1 (0.6)	6 (3.3 %)
	Primary School	5 (2.8 %)	2 (1.1 %)	27 (15 %)	10 (5.6 %)	5 (2.8 %)	68 (37.8 %)
	Junior Secondary School	0 (0 %)	7 (3.9 %)	3 (1.7 %)	3 (1.7 %)	4 (2.2 %)	24 (13.3 %)
	Senior Secondary School	51 (28.3 %)	47 (26.1 %)	79 (43.9 %)	53 (29.4 %)	25 (13.9 %)	72 (40 %)
	Technical School	20 (11.1 %)	15 (8.3 %)	3 (1.7 %)	1 (0.6 %)	16 (8.9 %)	0 (0 %)
	Vocational studies	2 (1.1 %)	8 (4.4 %)	9 (5.0 %)	1 (0.6 %)	8 (4.4 %)	0 (0 %)
	Tertiary Institution	50 (27.8 %)	85 (47.2 %)	47 (26.1 %)	64 (35.6 %)	121 (67.2 %)	10 (5.5 %)
Household Size	1	22 (12.2 %)	24 (13.3 %)	8 (4.4 %)	18 (10.0)	22 (12.2 %)	19 (10.6 %)
	2 - 5	29 (16.1 %)	120 (66.7 %)	99 (55 %)	91 (50.6 %)	134 (74.4 %)	120 (66.6)
	6 - 9	40 (22.2 %)	12 (6.7 %)	50 (27.8 %)	50 (27.8 %	22 (12.2 %)	33 (18.3)
	10 - 13	37 (20.6 %)	11 (6.1 %)	14 (7.8 %)	15 (8.3 %)	2 (1.1 %)	6 (3.3)
	14 - 17	0 (0 %)	10 (5.6 %)	1 (0.6 %)	3 (1.7 %)	0 (0 %)	0 (0 %)
	18 - 21	10 (5.6 %)	3 (1.7 %)	3 (1.7 %)	2 (1.1 %)	0 (0 %)	0 (0 %)
	More than 21	0 (0 %)	0 (0 %)	5 (2.8 %)	1 (0.6 %)	0 (0 %)	0 (0 %)

Number of	1	20 (11.1 %)	55 (30.6 %)	68 (37.8 %)	16 (8.9 %)	35 (19.4 %)	22 (12.2 %)
Dependants	2 - 5	56 (31.1 %)	89 (49.4 %)	79 (43.9 %)	123 (68.3 %)	128 (71.1 %)	131 (72.8 %)
	6 - 9	49 (27.2 %)	19 (10.6 %)	20 (11.1 %)	31 (17.2 %)	17 (9.4 %)	23 (12.8 %)
	10 - 13	44 (24.4 %)	12 (6.7 %)	6 (3.3 %)	5 (2.8 %)	0 (0 %)	4 (2.2 %)
	14 - 17	8 (4.4 %)	5 (2.8 %)	1 (0.6 %)	3 (1.7 %)	0 (0 %)	0 (0 %)
	18 - 21	1 (0.6 %)	0 (0 %)	1 (0.6 %)	2 (1.1 %)	0 (0 %)	0 (0 %)
	More than 21	2 (1.1 %)	0 (0 %)	5 (2.8 %)	0 (0 %)	0 (0 %)	0 (0 %)
Employment	Employed	130 (72.2 %)	119 (66.1 %)	74 (41.1 %)	142 (78.9 %)	150 (83.3 %)	130 (72.2 %)
Status	Unemployed	39 (21.7 %)	42 (23.3 %)	79 (43.9 %)	33 (18.3 %)	17 (9.4 %)	42 (23.3 %)
	Student/Apprentice	10 (5.6 %)	13 (7.2 %)	24 (13.3 %)	3 (1.7 %)	9 (5.0 %)	6 (3.3 %)
	Retired	1 (0.6 %)	6 (3.3 %)	3 (1.7 %)	2 (1.1 %)	4 (2.2 %)	2 (1.1 %)
Occupation	Trading	54.2 %	31.7 %	34.8 %	0 %	30.0 %	39.4 %
	Service Provision	2.8 %	22.0 %	28.4 %	89.5 %	30.5 %	3.7 %
	Farming	16.9 %	15.2 %	7.1 %	2.6 %	2.6 %	0 %
	Manufacturing	9.2 %	17.7 %	0.7 %	0 %	23.6 %	0 %
	Fishing	9.9 %	4.3 %	0.7 %	0 %	12.0 %	56.9 %

	None	7.0 %	9.1 %	28.4 %	7.9 %	1.3 %	0 %
Income	<N26,000	0 (0.0 %)	72 (34.5 %)	110 (61.1 %)	0 (0.0 %)	0 (0.0 %)	0 (0.0 %)
	N26,001-N52,000	5 (3.8 %)	3 (1.7 %)	41 (22.8 %)	42 (41.6 %)	1 (0.7 %)	3 (2.3 %)
	N52,001-N104,000	18 (13.8 %)	8 (4.4 %)	5 (2.8 %)	5 (5.0 %)	0 (0.0 %)	9 (6.9 %)
	N104,001-N156,000	21 (16.2 %)	18 (10.0 %)	2 (1.1 %)	2 (2.0 %)	2 (1.3 %)	1 (0.8 %)
	N156,001-N260,000	22 (16.9 %)	20 (11.1 %)	0 (0.0 %)	0 (0.0 %)	1 (0.7 %)	10 (7.7 %)
	N260,001-N415,000	39 (30.0 %)	31 (17.2 %)	5 (2.8 %)	5 (5.0 %)	6 (4.0 %)	25 (19.2 %)
	N415,001-N520,000	25 (19.2 %)	32 (17.8 %)	8 (4.4 %)	8 (7.9 %)	48 (32.0 %)	34 (26.2 %)
	>N520,001	0 (0.0 %)	6 (3.3 %)	9 (5.0 %)	39 (38.6 %)	92 (61.3 %)	48 (37.0 %)

Appendix D – Test of Perception Variations and Pairwise Comparisons

Table D1: Kruskal-Wallis Test on Various Perceptions Across Communities

Null Hypothesis	**df**	**Test Statistic (*H*)**	***p*-Value**	**Decision**
The distribution of climate events affecting households is the same across the communities.	7	281.668[a]	**<0.001***	Reject the null hypothesis
The distribution of the perception of migration drivers is the same across the communities.	8	8.108[a,b]	0.423	Retain the null hypothesis
The distribution of environment/climate push factors of migration is the same across the communities.	7	11.575[a,b]	0.115	Retain the null hypothesis
The distribution of environment/climate pull factors of migration is the same across the communities.	7	40.868[a]	**<0.001***	Reject the null hypothesis
The distribution of personal migration benefits is the same across the communities.	7	110.590[a]	**<0.001***	Reject the null hypothesis
The distribution of benefits of migration faced on the destination communities is the same across the communities.	7	25.867[a]	**<0.001***	Reject the null hypothesis
The distribution of challenges of migration faced by destination communities is the same across the communities.	7	41.729[a]	**<0.001***	Reject the null hypothesis
The distribution of causes of climate change is the same across the communities.	11	264.376[a]	**<0.001***	Reject the null hypothesis
The distribution of who leads discussions and interventions on environment and climate is the same across the communities.	11	37.326[a]	**<0.001***	Reject the null hypothesis

*** Significant at $p < 0.05$.**
[a.] The test statistic is adjusted for ties.
[b.] Pairwise comparisons are not performed because the overall test does not show significant differences across samples.

Table D2: Pairwise Comparisons on Perceptions of Climate Events Affecting Households

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
Odioma-Ogidigben	-61.661	29.455	-2.093	0.036	1.000
Odioma-Twon	128.856	29.455	4.375	0.000	0.000
Odioma-Tudun Nufawa	-190.894	29.455	-6.481	0.000	0.000
Odioma-Ugborodo	-249.350	29.455	-8.465	0.000	0.000
Odioma-Wako	-266.800	29.455	-9.058	0.000	0.000
Odioma-Zango	-297.367	29.455	-10.096	0.000	0.000
Odioma-Central	-403.783	29.455	-13.708	0.000	0.000
Ogidigben-Twon	67.194	29.455	2.281	0.023	0.631
Ogidigben-Tudun Nufawa	-129.233	29.455	-4.387	0.000	0.000
Ogidigben-Ugborodo	-187.689	29.455	-6.372	0.000	0.000
Ogidigben-Wako	-205.139	29.455	-6.964	0.000	0.000
Ogidigben-Zango	-235.706	29.455	-8.002	0.000	0.000
Ogidigben-Central	-342.122	29.455	-11.615	0.000	0.000
Twon-Tudun Nufawa	-62.039	29.455	-2.106	0.035	0.985
Twon-Ugborodo	-120.494	29.455	-4.091	0.000	0.001
Twon-Wako	-137.944	29.455	-4.683	0.000	0.000
Twon-Zango	-168.511	29.455	-5.721	0.000	0.000
Twon-Central	-274.928	29.455	-9.334	0.000	0.000
Tudun Nufawa-Ugborodo	-58.456	29.455	-1.985	0.047	1.000
Tudun Nufawa-Wako	-75.906	29.455	-2.577	0.010	0.279
Tudun Nufawa-Zango	-106.472	29.455	-3.615	0.000	0.008
Tudun Nufawa-Central	-212.889	29.455	-7.228	0.000	0.000
Ugborodo-Wako	-17.450	29.455	-0.592	0.554	1.000
Ugborodo-Zango	48.017	29.455	1.630	0.103	1.000
Ugborodo-Central	-154.433	29.455	-5.243	0.000	0.000
Wako-Zango	30.567	29.455	1.038	0.299	1.000
Wako-Central	136.983	29.455	4.651	0.000	0.000
Zango-Central	-106.417	29.455	-3.613	0.000	0.008

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is .050.
a. Significance values have been adjusted by the Bonferroni correction for multiple tests.

Table D3: Pairwise Comparisons of Perceptions of Climatic/Environmental Pull Factors of Migration is the Same Across the Communities.

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
Wako-Tudun_Nufawa	-10.651	24.922	-0.427	0.669	1.000
Wako-Zango	25.953	24.722	1.050	0.294	1.000
Wako-Sabon_Gari_East	55.713	23.622	2.358	0.018	0.514
Wako-Zuba	74.940	23.497	3.189	0.001	0.040
Wako-Sabon_Gari_West	80.392	23.921	3.361	0.001	0.022
Wako-Central	81.958	27.439	2.987	0.003	0.079
Wako-Tungamaje	83.753	24.305	3.446	0.001	0.016
Tudun_Nufawa-Zango	15.302	18.134	0.844	0.399	1.000
Tudun_Nufawa-Sabon_Gari_East	45.062	16.604	2.714	0.007	0.186
Tudun_Nufawa-Zuba	64.289	16.425	3.914	0.000	0.003
Tudun_Nufawa-Sabon_Gari_West	69.741	17.025	4.096	0.000	0.001
Tudun_Nufawa-Central	71.307	21.692	3.287	0.001	0.028
Tudun_Nufawa-Tungamaje	73.102	17.561	4.163	0.000	0.001
Zango-Sabon_Gari_East	-29.760	16.301	-1.826	0.068	1.000
Zango-Zuba	-48.986	16.119	-3.039	0.002	0.066
Zango-Sabon_Gari_West	-54.438	16.730	-3.254	0.001	0.032
Zango-Central	-56.005	21.461	-2.610	0.009	0.254
Zango-Tungamaje	-57.800	17.275	-3.346	0.001	0.023
Sabon_Gari_East-Zuba	19.227	14.376	1.337	0.181	1.000
Sabon_Gari_East-Sabon_Gari_West	24.678	15.058	1.639	0.101	1.000
Sabon_Gari_East-Central	-26.245	20.185	-1.300	0.194	1.000
Sabon_Gari_East-Tungamaje	28.040	15.662	1.790	0.073	1.000
Zuba-Sabon_Gari_West	-5.452	14.861	-0.367	0.714	1.000
Zuba-Central	-7.019	20.038	-0.350	0.726	1.000
Zuba-Tungamaje	-8.813	15.472	-0.570	0.569	1.000
Sabon_Gari_West-Central	-1.567	20.533	-0.076	0.939	1.000
Sabon_Gari_West-Tungamaje	3.362	16.108	0.209	0.835	1.000
Central-Tungamaje	1.795	20.980	0.086	0.932	1.000

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is .050.
a. Significance values have been adjusted by the Bonferroni correction for multiple tests.

Table D4: Pairwise Comparisons on Perceptions on Personal Migration Benefits of Migration

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
Zango-Tudun Nufawa	-171.989	27.087	-6.350	0.000	0.000
Zango-Central	-186.833	27.969	-6.680	0.000	0.000
Zango-Sabon Gari West	-198.524	27.500	-7.219	0.000	0.000
Zango-Zuba	-204.539	24.033	-8.511	0.000	0.000
Zango-Wako	-217.038	27.806	-7.806	0.000	0.000
Zango-Sabon Gari East	-227.429	24.230	-9.386	0.000	0.000
Zango-Tungamaje	-249.074	26.837	-9.281	0.000	0.000
Tudun Nufawa-Central	-14.844	26.079	-0.569	0.569	1.000
Tudun Nufawa-Sabon Gari West	-26.535	25.575	-1.038	0.299	1.000
Tudun Nufawa-Zuba	-32.550	21.804	-1.493	0.135	1.000
Tudun Nufawa-Wako	-45.049	25.904	-1.739	0.082	1.000
Tudun Nufawa-Sabon Gari East	-55.440	22.021	-2.518	0.012	0.331
Tudun Nufawa-Tungamaje	-77.086	24.861	-3.101	0.002	0.054
Central-Sabon Gari West	-11.690	26.508	-0.441	0.659	1.000
Central-Zuba	-17.706	22.891	-0.773	0.439	1.000
Central-Wako	30.204	26.825	1.126	0.260	1.000
Central-Sabon Gari East	-40.595	23.098	-1.758	0.079	1.000
Central-Tungamaje	-62.241	25.820	-2.411	0.016	0.446
Sabon Gari West-Zuba	6.016	22.315	0.270	0.787	1.000
Sabon Gari West-Wako	18.514	26.335	0.703	0.482	1.000
Sabon Gari West-Sabon Gari East	28.905	22.527	1.283	0.199	1.000
Sabon Gari West-Tungamaje	50.551	25.311	1.997	0.046	1.000
Zuba-Wako	12.498	22.691	0.551	0.582	1.000
Zuba-Sabon Gari East	-22.889	18.133	-1.262	0.207	1.000
Zuba-Tungamaje	44.535	21.494	2.072	0.038	1.000
Wako-Sabon Gari East	-10.391	22.900	-0.454	0.650	1.000
Wako-Tungamaje	-32.037	25.643	-1.249	0.212	1.000
Sabon Gari East-Tungamaje	21.646	21.714	0.997	0.319	1.000

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is .050.
a. Significance values have been adjusted by the Bonferroni correction for multiple tests.

Table D5: Pairwise Comparisons of Perceptions on Migration Benefits On Destination Communities

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
Sabon Gari West-Sabon Gari East	-17.992	20.835	-0.864	0.388	1.000
Sabon Gari West-Zango	21.027	24.424	0.861	0.389	1.000
Sabon Gari West-Zuba	-23.710	20.249	-1.171	0.242	1.000
Sabon Gari West-Tudun Nufawa	26.642	25.182	1.058	0.290	1.000
Sabon Gari West-Wako	53.054	26.368	2.012	0.044	1.000
Sabon Gari West-Central	72.739	26.105	2.786	0.005	0.149
Sabon Gari West-Tungamaje	96.803	23.376	4.141	0.000	0.001
Sabon Gari East-Zango	3.036	22.267	0.136	0.892	1.000
Sabon Gari East-Zuba	-5.718	17.587	-0.325	0.745	1.000
Sabon Gari East-Tudun Nufawa	8.651	23.096	0.375	0.708	1.000
Sabon Gari East-Wako	35.063	24.384	1.438	0.150	1.000
Sabon Gari East-Central	54.747	24.099	2.272	0.023	0.647
Sabon Gari East-Tungamaje	78.812	21.113	3.733	0.000	0.005
Zango-Zuba	-2.682	21.720	-0.124	0.902	1.000
Zango-Tudun Nufawa	5.615	26.379	0.213	0.831	1.000
Zango-Wako	32.027	27.513	1.164	0.244	1.000
Zango-Central	51.711	27.261	1.897	0.058	1.000
Zango-Tungamaje	-75.776	24.661	-3.073	0.002	0.059
Zuba-Tudun NuFawa	2.933	22.569	0.130	0.897	1.000
Zuba-Wako	29.344	23.885	1.229	0.219	1.000
Zuba-Central	49.029	23.594	2.078	0.038	1.000
Zuba-Tungamaje	73.094	20.534	3.560	0.000	0.010
Tudun NuFawa-Wako	26.412	28.189	0.937	0.349	1.000
Tudun NuFawa-Central	46.096	27.943	1.650	0.099	1.000
Tudun NuFawa-Tungamaje	-70.161	25.412	-2.761	0.006	0.161
Wako-Central	-19.684	29.016	-0.678	0.498	1.000
Wako-Tungamaje	-43.749	26.588	-1.645	0.100	1.000
Central-Tungamaje	-24.065	26.327	-0.914	0.361	1.000

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is .050.
a. Significance values have been adjusted by the Bonferroni correction for multiple tests.

Table D6: Pairwise Comparisons of Perceptions on Migration Challenges on Communities

Sample 1-Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig.[a]**
Sabon_Gari_West-Central	-2.293	24.629	-0.093	0.926	1.000
Sabon_Gari_West-Sabon_Gari_East	6.796	19.806	0.343	0.731	1.000
Sabon_Gari_West-Zuba	-7.308	18.353	-0.398	0.690	1.000
Sabon_Gari_West-Wako	-7.646	27.284	-0.280	0.779	1.000
Sabon_Gari_West-Tudun Nufawa	-53.834	23.706	-2.271	0.023	0.648
Sabon_Gari_West-Zango	-58.531	23.503	-2.490	0.013	0.357
Sabon_Gari_West-Tungamaje	-104.739	21.667	-4.834	0.000	**0.000**
Central-Sabon_Gari_East	4.503	23.322	0.193	0.847	1.000
Central-Zuba	5.015	22.101	0.227	0.821	1.000
Central-Wako	-5.353	29.934	-0.179	0.858	1.000
Central-Tudun Nufawa	-51.540	26.714	-1.929	0.054	1.000
Central-Zango	-56.238	26.534	-2.119	0.034	0.953
Central-Tungamaje	102.445	24.922	4.111	0.000	**0.001**
Sabon_Gari_East-Zuba	-0.512	16.559	-0.031	0.975	1.000
Sabon_Gari_East-Wako	-0.850	26.111	-0.033	0.974	1.000
Sabon_Gari_East-Tudun Nufawa	-47.037	22.346	-2.105	0.035	0.988
Sabon_Gari_East-Zango	-51.735	22.131	-2.338	0.019	0.543
Sabon_Gari_East-Tungamaje	-97.942	20.170	-4.856	0.000	**0.000**
Zuba-Wako	-0.338	25.026	-0.014	0.989	1.000
Zuba-Tudun Nufawa	-46.525	21.068	-2.208	0.027	0.762
Zuba-Zango	-51.223	20.840	-2.458	0.014	0.391
Zuba-Tungamaje	97.431	18.744	5.198	0.000	**0.000**
Wako-Tudun Nufawa	-46.187	29.180	-1.583	0.113	1.000
Wako-Zango	-50.885	29.016	-1.754	0.079	1.000
Wako-Tungamaje	97.092	27.549	3.524	0.000	**0.012**
Tudun Nufawa-Zango	-4.698	25.680	-0.183	0.855	1.000
Tudun Nufawa-Tungamaje	50.905	24.010	2.120	0.034	0.952
Zango-Tungamaje	46.207	23.810	1.941	0.052	1.000

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is .050.
a. Significance values have been adjusted by the Bonferroni correction for multiple tests.

Table D7: Pairwise Comparisons of Perceptions on Causes of Climate Change

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
Odioma-Wako	135.468	68.810	1.969	0.049	1.000
Odioma-Zuba	172.070	67.260	2.558	0.011	0.694
Odioma-Tungamaje	179.250	73.289	2.446	0.014	0.954
Odioma-Zango	206.631	74.104	2.788	0.005	0.350
Odioma-Central	247.178	66.774	3.702	0.000	0.014
Odioma-Sabon Gari East	279.991	61.401	4.560	0.000	0.000
Odioma-Twon	298.189	73.095	4.079	0.000	0.003
Odioma-Sabon Gari West	369.936	62.574	5.912	0.000	0.000
Odioma-Tudun Nufawa	476.744	63.415	7.518	0.000	0.000
Odioma-Ugborodo	-626.382	62.289	-10.056	0.000	0.000
Odioma-Ogidigben	-678.234	64.200	-10.564	0.000	0.000
Wako-Zuba	-36.602	62.576	-0.585	0.559	1.000
Wako-Tungamaje	-43.782	69.016	-0.634	0.526	1.000
Wako-Zango	-71.164	69.880	-1.018	0.309	1.000
Wako-Central	111.710	62.053	1.800	0.072	1.000
Wako-Sabon Gari East	-144.524	56.231	-2.570	0.010	0.671
Wako-Twon	-162.722	68.810	-2.365	0.018	1.000
Wako-Sabon Gari West	-234.469	57.510	-4.077	0.000	0.003
Wako-Tudun Nufawa	-341.277	58.423	-5.841	0.000	0.000
Wako-Ugborodo	-490.914	57.200	-8.582	0.000	0.000
Wako-Ogidigben	-542.766	59.275	-9.157	0.000	0.000
Zuba-Tungamaje	-7.180	67.471	-0.106	0.915	1.000
Zuba-Zango	-34.562	68.355	-0.506	0.613	1.000
Zuba-Central	75.108	60.330	1.245	0.213	1.000
Zuba-Sabon Gari East	-107.922	54.324	-1.987	0.047	1.000
Zuba-Twon	-126.120	67.260	-1.875	0.061	1.000
Zuba-Sabon Gari West	-197.867	55.647	-3.556	0.000	0.025
Zuba-Tudun Nufawa	-304.675	56.590	-5.384	0.000	0.000
Zuba-Ugborodo	-454.312	55.326	-8.212	0.000	0.000
Zuba-Ogidigben	-506.164	57.469	-8.808	0.000	0.000
Tungamaje-Zango	-27.382	74.295	-0.369	0.712	1.000
Tungamaje-Central	67.928	66.986	1.014	0.311	1.000
Tungamaje-Sabon Gari East	-100.742	61.632	-1.635	0.102	1.000
Tungamaje-Twon	-118.940	73.289	-1.623	0.105	1.000
Tungamaje-Sabon Gari West	-190.687	62.801	-3.036	0.002	0.158

Tungamaje-Tudun Nufawa	-297.495	63.638	-4.675	0.000	0.000
Tungamaje-Ugborodo	-447.132	62.517	-7.152	0.000	0.000
Tungamaje-Ogidigben	-498.984	64.421	-7.746	0.000	0.000
Zango-Central	40.546	67.876	0.597	0.550	1.000
Zango-Sabon Gari East	-73.360	62.598	-1.172	0.241	1.000
Zango-Twon	-91.558	74.104	-1.236	0.217	1.000
Zango-Sabon Gari West	-163.305	63.749	-2.562	0.010	0.687
Zango-Tudun Nufawa	-270.113	64.574	-4.183	0.000	0.002
Zango-Ugborodo	-419.751	63.470	-6.613	0.000	0.000
Zango-Ogidigben	-471.603	65.346	-7.217	0.000	0.000
Central-Sabon Gari East	-32.814	53.721	-0.611	0.541	1.000
Central-Twon	-51.012	66.774	-0.764	0.445	1.000
Central-Sabon Gari West	-122.759	55.057	-2.230	0.026	1.000
Central-Tudun Nufawa	-229.567	56.011	-4.099	0.000	0.003
Central-Ugborodo	-379.204	54.734	-6.928	0.000	0.000
Central-Ogidigben	-431.056	56.899	-7.576	0.000	0.000
Sabon Gari East-Twon	-18.198	61.401	-0.296	0.767	1.000
Sabon Gari East-Sabon Gari West	89.945	48.402	1.858	0.063	1.000
Sabon Gari East-Tudun Nufawa	196.753	49.483	3.976	0.000	0.005
Sabon Gari East-Ugborodo	-346.391	48.033	-7.212	0.000	0.000
Sabon Gari East-Ogidigben	-398.243	50.486	-7.888	0.000	0.000
Twon-Sabon Gari West	71.747	62.574	1.147	0.252	1.000
Twon-Tudun Nufawa	178.555	63.415	2.816	0.005	0.321
Twon-Ugborodo	-328.193	62.289	-5.269	0.000	0.000
Twon-Ogidigben	-380.045	64.200	-5.920	0.000	0.000
Sabon Gari West-Tudun Nufawa	106.808	50.931	2.097	0.036	1.000
Sabon Gari West-Ugborodo	-256.446	49.524	-5.178	0.000	0.000
Sabon Gari West-Ogidigben	-308.298	51.907	-5.939	0.000	0.000
Tudun Nufawa-Ugborodo	-149.638	50.581	-2.958	0.003	0.204
Tudun Nufawa-Ogidigben	-201.490	52.917	-3.808	0.000	0.009
Ugborodo-Ogidigben	51.852	51.563	1.006	0.315	1.000

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is .050.
a. Significance values have been adjusted by the Bonferroni correction for multiple tests.

Appendix E – Linking Activities Leading to Land Degradation

Table E1: Multinomial Logistic Regression Model Outcome for Activities Leading to Land Degradation at the Destination Communities

Location	**Model**	**Model Fitting Criteria**			**Likelihood Ratio Test**			**R^2 (Nagelkerke)**
		AIC	BIC	−2 Log Likelihood	X^2	df	Sig.	
Sabon Gari East	Intercept	255.65	148.21	327.18	36.65	12	<0.001 *	0.166
	Final	108.32	395.29	223.65				
Sabon Gari West	Intercept	235.08	145.08	198.35	49.31	12	<0.001 *	0.225
	Final	149.14	189.53	117.14				
Zuba	Intercept	218.50	164.45	230.30	76.66	12	<0.001 *	0.391
	Final	155.65	195.24	123.65				
Tungamaje	Intercept	335.48	245.08	227.08	69.91	12	<0.001 *	0.221
	Final	234.34	248.97	130.33				

*** Significant at $p < 0.05$**.

Table E2: Likelihood Ratio Tests of Multinomial Logistic Regression for Specific Perceived Activities Leading to Land Degradation in each Community

Effect	Sabon Gari East			Sabon Gari West			Zuba			Tungamaje		
******Y*	X^2	df	*p*-Value	X^2	df	*p*-Value	X^2	df	*p*-Value	X^2	df	*p*-Value
Deforestation/Vegetation loss (X_1)	15.79	5	0.257	22.92	5	0.546	12.59	6	<0.001**	-	-	-
Pressure on land for development (X_2)	14.66	5	<0.001**	13.74	5	<0.001**	15.82		-	-	-	-
Soil quality depletion (X_3)	21.58	5	0.127	43.01	5	0.325	-	-	-	56.23	9	0.701
Pressure on agricultural land (X_4)	-	-	-	-		-			-	23.76	9	0.130

*** Land degradation process (dependent variable)**
**** Significant at $p < 0.05$.**