Community-Based Responses and Adaptations to Climate Change: A Case Study in Omusati Region, Namibia.

By

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ABSTRACT

This study investigates community-based responses and adaptation strategies to climate change in the Omusati Region of Namibia, a semi-arid area where rural livelihoods are predominantly reliant on subsistence agriculture and livestock. The region faces increased vulnerability from climate variability, characterized by erratic rainfall patterns, prolonged droughts, and rising temperatures, which threaten food security and socio-economic stability. The research aims to assess the Omusati communities' understanding of climate change, their adaptive capacities, and the effectiveness of existing adaptation practices. Using a mixed-methods approach, the study combines quantitative surveys and qualitative interviews with farmers, local leaders, and key informants. Data collected explores how demographics, resource availability, and local knowledge influence perceptions and adaptive behaviors.

Findings indicate that communities in Omusati employ a range of adaptation strategies, such as crop diversification, drought-resistant crop varieties, water harvesting, livestock stocking control, and supplementary feeding for livestock. These strategies, while essential for resilience, are often constrained by limited access to resources, market barriers, and inadequate infrastructure. Additionally, the study reveals the significant role of traditional knowledge and social support networks in shaping local adaptation, highlighting the strengths and limitations of community-driven strategies in the face of climate challenges. Analysis also shows that awareness of climate change is generally high among community members, but implementation of advanced adaptation practices is hindered by limited technical expertise and government support.

The study concludes that while Omusati's adaptation strategies contribute to resilience, they require reinforcement through enhanced institutional support, targeted policy interventions, and increased capacity-building efforts. Recommendations include integrating local adaptation insights into national and regional climate policies, improving resource access through subsidies or financial support for sustainable agriculture, and enhancing training in climate-smart agricultural practices. Furthermore, establishing collaborative frameworks between communities, government bodies, and NGOs could facilitate the development of resilient infrastructure and technical support mechanisms. This research contributes to the broader discourse on climate resilience in rural African contexts, emphasizing the importance of grassroots adaptation measures to promote sustainable development in vulnerable regions like Omusati. It underscores the necessity for adaptive policies that are inclusive of local knowledge and needs, offering a model for strengthening climate resilience in similar environments across Namibia and beyond.

Keywords: Climate Change Adaptation**,** Community Resilience**,** Subsistence Agriculture**,** Traditional Knowledge**,** Rural Livelihoods**,** Semi-Arid Regions

AUTHOR'S DECLARATION

I, Moses Italeni Hitilasha (St. No. 201725924), declare that this is my own work, and it has not been submitted to any other degree at the University of the Free State or any other University or any other higher education institution, and that all resources that I have used or quoted are indicated in the text and acknowledged in the list of references.



Moses Italeni Hitilasha

DEDICATION

“I dedicate this mini dissertation to my late father, my mother, my wife, my children and family. You guys are my support system!”

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First and foremost, I would like to thank my almighty god for his mercy, guidance and providing me with wisdom and strength to accomplish this task.

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ACRONYMS AND ABBREVIATIONS

ASSA	Actuarial Society of South Africa
CBA	Community-Based Adaptation
CARIAA	Collaborative Adaptation Research Initiative in Africa and Asia
CARL	Climate Adaptation for Rural Livelihoods
CBO	Community-Based Organization
CC	Climate Change
CCA	Climate Change Adaptation
COP	Conference of the Parties
CRIDF	Climate Resilient Infrastructure Development Facility
DEA	Department of Environmental Affairs
DEATF	Department of Environmental Affairs, Tourism, and Forestry
DRR	Disaster Risk Reduction
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GIZ	German Corporation for International Cooperation
IFAD	International Fund for Agricultural Development
IPCC	Intergovernmental Panel on Climate Change
KAP	Knowledge, Attitudes, and Practices
LDC	Least Developed Countries
MAWF	Ministry of Agriculture, Water, and Forestry
MCA	Millennium Challenge Account
MET	Ministry of Environment and Tourism

NAPA	National Adaptation Programme of Action
NGO	Non-Governmental Organization
NPC	National Planning Commission
NSA	Namibia Statistics Agency
NSS	National Statistics System
PRA	Participatory Rural Appraisal
SDGs	Sustainable Development Goals
SLA	Sustainable Livelihood Approach
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations Children's Fund
UNISDR	United Nations International Strategy for Disaster Reduction
UNOCHA	United Nations Office for the Coordination of Humanitarian Affairs
USAID	United States Agency for International Development
UVC	Universal Vulnerability Classification
V&A	Vulnerability and Adaptation
WHO	World Health Organization

Chapter 1: Introduction

1.1 Introduction

The global community has increasingly recognized climate change as one of the most significant environmental and social challenges facing humanity. The Intergovernmental Panel on Climate Change (IPCC, 2021) states that climate change poses a profound risk to ecosystems, food security, water availability, and human livelihoods, especially in vulnerable regions. Southern

Africa, where Namibia is located, is experiencing climate change impacts, with frequent droughts, erratic rainfall, and rising temperatures. The region's dependence on agriculture exacerbates the situation, as agriculture is highly sensitive to climatic changes Food and Agriculture Organization (FAO, 2019). Namibia is not exempt from the impacts of climate change due to its location in this region. Characterized by its arid and semi-arid climate, the country has seen an increasing frequency and intensity of climate change-related events, such as prolonged droughts, unpredictable rainfall patterns, and rising temperatures (Department of Environmental Affairs, Tourism and Forestry (DEATF), 2019). According to Moyo et al. (2022), the changes are more pronounced in rural regions like Omusati, where livelihoods are largely dependent on agriculture and natural resources. As such, community-based responses and adaptations to climate change are critical in areas such as the Omusati Region of Namibia, where rural communities rely heavily on natural resources for their livelihoods.

In Namibia, where over 70% of the population depends on subsistence agriculture (Namibia Statistics Agency (NSA), 2020), communities have developed both traditional and contemporary responses to climate change and variability. Communities have developed a variety of adaptation strategies that draw on traditional knowledge and localized practices (United Nations Development Programme (UNDP), 2020). These responses are crucial in mitigating the impacts of droughts, floods, and unpredictable weather patterns, which threaten food security and economic stability (Mendelsohn et al., 2002). However, research and understanding into the perspectives, strategies, and vulnerabilities of rural communities in Namibia remains limited. Existing studies emphasize national-level policies or the ecological impacts of climate change, with insufficient analysis of how local communities perceive and adapt to these changes (Newsham & Thomas, 2011).

This study, therefore, seeks to bridge this gap by exploring community-based responses and adaptations to climate change in the Omusati Region. The Omusati Region, located in the north-western part of Namibia, is particularly vulnerable to climate change due to its dependence on rain-fed agriculture and its arid environment. By first understanding the local perspectives, adaptive strategies, and vulnerabilities of the communities in Omusati, this research aims to contribute to the development of sustainable and context-specific climate change adaptation strategies.

1.2 Background

Worldwide, climate change is widely recognized as a critical issue that affects all aspects of human life and environmental systems. According to the United Nations Framework Convention on Climate Change (UNFCCC, 2020), the impacts of climate change are already being felt across the globe, with developing countries experiencing the greatest burden due to their limited resources for adaptation. Namibia, with an average annual rainfall of less than 250 mm in many areas, is one of the driest countries in sub-Saharan Africa (Mendelsohn et al., 2002). Consequently, rural communities in regions like Omusati are vulnerable to climate-related shocks, including droughts, floods, and extreme weather events.

The Omusati Region, located in the Cuvelai Basin, is largely dependent on subsistence crop and livestock farming for livelihoods. Communal Farmers in this region practice small-scale agriculture, often growing millet (mahangu), sorghum, and maize, alongside rearing cattle, goats, and sheep. These agricultural activities are highly sensitive to climatic fluctuations, and the increasing unpredictability of rainfall and temperature extremes poses a direct threat to food security and income generation in the region (Mendelsohn et al., 2002). As expounded by Dirkx et al. (2008), Namibia's agricultural sector is particularly vulnerable to the effects of climate change, with smallholder farmers facing heightened risks due to their reliance on natural rainfall for crop production.

In response to these challenges, communities in Omusati have employed various strategies to mitigate and adapt to climate change. Reid et al. (2007) identified that these strategies range from traditional practices, such as intercropping and crop rotation, to more contemporary approaches, including the use of improved seed varieties and the adoption of water-saving technologies. Recently, migration has emerged as an adaptation strategy, with some community members moving to urban areas or neighboring regions in search of better economic opportunities (Kamwi et al., 2021).

However, the success of these adaptation strategies is contingent on several factors, including access to resources, knowledge dissemination, institutional support, and local governance. O'Brien et al. (2009) noted that adaptive capacity varies significantly between communities, depending on their access to economic and social resources, governance structures, and the availability of information about climate risks and adaptation options.

1.3 Study Rationale

The significance of this study stems from the need to understand the specific responses and adaptations employed by communities in the Omusati Region to cope with the impacts of climate change. While there is a growing body of literature on climate change adaptation globally, much of this research has focused on institutional or national-level responses, with less emphasis on community-based strategies (Newsham & Thomas, 2011). In Namibia, there is a critical need to document and analyze the perspectives and practices of rural communities, particularly in regions like Omusati that are at the frontline of climate impacts.

Community-based adaptation strategies are an essential element of climate change adaptation for several reasons. Firstly, they are grounded in local knowledge and practices, which have been honed over several generations to cope with environmental variability. According to Berkes et al. (2000), traditional ecological knowledge plays an important role in shaping community responses to environmental change, and its integration into formal adaptation planning can enhance the resilience of vulnerable populations. Secondly, community-driven responses are often more flexible and responsive to local conditions than top-down approaches, which often do not align with the needs and priorities of specific rural populations (Ensor & Berger, 2009).

Above all, understanding the social dimensions of climate change adaptation is critical. Adger et al. (2003) noted that the success of adaptation strategies depends not only on the availability of technical solutions but also on the social, cultural, and economic contexts in which these strategies are implemented. In the Omusati Region, where communities are facing increasing pressures from both climate change and socio-economic challenges, it is important to explore how local perceptions and access to resources influence adaptation outcomes.

This study is particularly timely given the growing recognition of the need for locally driven climate adaptation strategies. Namibia's National Climate Change Strategy and Action Plan (2013–2020) emphasizes the importance of community participation in climate change adaptation; however, there is limited empirical research documenting how communities in regions like Omusati are responding to climate change at the grassroots level (Republic of Namibia, 2014). By contributing to this knowledge base, this study aims to inform both policy and practice in developing more effective and context-specific climate adaptation strategies.

1.4 Research Question

This study is guided by the following research questions:

- How do communities in the Omusati Region perceive the changes in their local climate, and what indicators do they use to assess these changes?
- What community-based adaptation strategies have been implemented in the Omusati Region to cope with the impacts of climate change?
- What factors influence the adaptive capacity and vulnerability of communities in the Omusati Region in response to climate change?
- What key areas of concern should be addressed in a climate change adaptation strategy tailored for the Omusati Region?

These questions will be explored through an examination of local perspectives on climate change, the specific adaptation strategies employed by communities, and the factors influencing the success or failure of these strategies. In particular, the study will investigate the effect of traditional knowledge and access to resources on community-based responses to climate change.

1.5 Research Objectives

The primary objective of this study is:

> To explore and analyze community-based responses and adaptations to climate change in the Omusati Region of Namibia.

This main objective will guide the investigation of community perspectives, adaptation strategies, and vulnerabilities, to develop recommendations for more effective climate adaptation policies and practices. In addition to the main research objective, this study is guided by the following specific objectives:

- To assess local community perceptions and knowledge of climate change impacts in the Omusati Region.
- To identify and evaluate the effectiveness of existing community-based adaptation strategies to climate variability and change.
- To analyze the adaptive capacity and vulnerability of households to climate risks, to inform the development of a localized Climate Change Adaptation Strategy.

1.6 Structure of the Study

The dissertation is organized into five chapters, each addressing a different aspect of the research process:

- **Chapter 1: Introduction**: This chapter provides an overview of the research topic, including the background, rationale, research question, objectives, and significance of the study. It also outlines the structure of the thesis.
- **Chapter 2: Literature Review**: This chapter reviews the relevant literature on climate change adaptation, with a particular focus on community-based responses. It examines key concepts such as vulnerability, resilience, and adaptive capacity, as well as the role of traditional knowledge and governance in shaping climate adaptation strategies.
- **Chapter 3: Methodology**: This chapter describes the research design and methodology used in the study. It outlines the data collection methods, including surveys, interviews, and field observations, and provides an explanation of the data analysis techniques employed.
- **Chapter 4: Results and Discussion**: This chapter presents the findings of the study and discusses them in relation to the research objectives. It provides an analysis of community perspectives on climate change, existing adaptation strategies, and the capacity and vulnerability of communities to cope with climate change impacts.
- **Chapter 5: Conclusion and Recommendations**: The final chapter summarizes the key findings of the study and provides recommendations for future climate adaptation strategies. It also identifies areas for further research and highlights the implications of the study for policy and practice.

This structure is designed to provide a comprehensive exploration of community-based responses to climate change in the Omusati Region and to contribute to the development of effective, locally grounded adaptation strategies.

Chapter 2: Literature Review

2.1 Introduction to Climate Change

Climate is the statistical distribution of weather patterns in an area over a significant period, typically thirty years or more (Trenberth et al., 2007). According to Hartmann et al. (2013) climatic conditions are derived from meteorological parameters that result from varying angles of the Earth

to the Sun. The Earth's elliptical shape and rotation causes distance variations of the Sun from the Earth's surface, which causes uneven heat distribution and irregular climatic conditions, creating different climate conditions for different areas (Karl & Trenberth, 2003). The Earth's aqueous and terrestrial reserves enable it to absorb and release heat, maintaining stable climatic conditions. On the other hand, climate change is the alteration of the normal pattern of weather, regionally or globally, throughout periods (IPCC, 2014). Climate changes are natural phenomena that sometimes show obvious and hidden effects with universal impacts. Mendelsohn et al., (2002) observed that recent trends have sped up the impacts, causing near and extreme effects that have significant socio-economic consequences on humans and the environment. These universal impacts have led scientists to question whether human activities are causing the speed and effects of global warming. UNDP (2015) argues that fast-growing, diverse human activities, human population, urbanization, industrialization, and waste generation, which produce harmful gases, deplete the ozone layer, and contribute to the greenhouse effect, are causing variations in weather patterns everywhere.

2.1.1 Global and Regional Impacts of Climate Change

A thorough knowledge and understanding of climate change impacts is necessary to design adaptation programs that meet the needs of diverse sectors and people (Adger et al., 2003; Ensor & Berger, 2009). These impacts are experienced at various levels, including locally, nationally, regionally, and internationally (Newsham & Thomas, 2011). Through a combination of natural and anthropogenic processes, climate change impacts are experienced by altering atmospheric and geographic or community conditions (Karl & Trenberth, 2003). According to the UNDP (2015) many impacts are indirect in that poor communities may already be facing development challenges, such as limited access to credit, education, or markets. The World Health Organization (WHO, 2018) notes that where there is a convergence of multiple climate-related hazards and underlying social, ecological, and economic vulnerabilities, a greater synthesis of health research and an evaluation of climate change interaction contributes to the significance of climate change consequences. As a result, climate change in most cases exacerbates the impact of existing development challenges on already vulnerable communities at present (IPCC, 2014). It is important to place climate change adaptation strategies in the context of regional and local level development processes and to draw on both indigenous knowledge and scientific knowledge to show that multi-vector action of climate change is helpful (Berkes et al., 2000). In addition, understanding the extent to which the development of the region and associated strategies can adapt to climate change impacts is required.

2.1.2 Specific Climate Challenges in Omusati Region

The Omusati region of Namibia is identified as one of the high vulnerability areas to climate variability and change (Moyo et al., 2022; Benguela Current Commission, 2019). Reid et al. (2007) and Berkes et al. (2000) argue that knowledge of rural communities about climate change and their local adaptation strategies is important to inform comprehensive strategies that address the challenge. Although it is acknowledged that the Omusati region is a rural area and is generally faced with various issues, the described extreme climate conditions and their associated impacts on agricultural activities are the greatest challenge (Angula, 2016). This consequently affects water availability for households and livestock (Benguela Current Commission, 2019). The recurrent prolonged droughts over the years are said to not only result in households that rely on food aid but also in the continuous presence of food stock throughout the year (Mendelsohn et al., 2002). According to WHO (2018) the shortage of water in the dry season and the presence of waterborne and respiratory diseases in the region are pointed out as indicative of drought episodes. The observation of temperature increases and high evaporation rates by Karl and Trenberth (2003) has contributed to lowering water levels in rivers, which has led to the reduction or total depletion of river flow and continues to limit water access for households and livestock. Small stock, such as chickens, have been observed collapsing because of extreme temperatures, and water scarcity leads to increased expenditures for households or having no access to water at all.

2.1.3 Concept of Climate Change Adaptation

Climate change adaptation is embedded in the framework of sustainable development since the ultimate aims of both are to ensure the well-being of people by fulfilling social, economic, and environmental needs (Mapani et al., 2023; Engelhard et al., 2024; Mupambwa et al., 2021). Climate change adaptation aims to respond to and mitigate the risks associated with climate change. The economic, social, and environmental impacts of climate change require enhanced adaptive responses to address these impacts, such as a great effort in bringing about technological transformations and behavioral changes, as well as the integration of environmental dimensions in development plans.

The climatic system forms an integral part of life on our planet, and any alteration to this system has profound and direct repercussions on the socio-economic status of communities worldwide, particularly in Africa (IPCC, 2014; UNDP, 2015). While Mendelsohn et al. (2002) argued that climate change does not solely yield adverse effects, the negative impacts of such change far outweigh any positive ones. One region identified as particularly susceptible to these changes is

the Omusati region, where most inhabitants rely on natural resource-based activities, primarily within the agricultural sector (Angula, 2016; Department of Environmental Affairs, Tourism and Forestry, 2019). It is therefore imperative that communities in the Omusati region respond and adapt to these changes accordingly. Berkes et al. (2000) note that as residents become increasingly aware of the effects of climate change, the incorporation of local adaptive capacity and knowledge can greatly enhance the development of effective adaptation strategies. Focusing on the Omusati Region, the correlation between climate change and food security in communal areas is noted and emphasized (Moyo et al., 2022). Additionally, a theoretical framework is needed to comprehend the interplay between climate change, food security, and community-based adaptation strategies.

2.1.4 Significance of Adapting to Changing Climate Conditions

Despite ongoing progress in our understanding of the impacts of climate change and variability, scientific understanding of how local communities respond and adapt to these changes remains limited (Degroot et al., 2021). Documented climate impacts have generally been based on data and information derived from historical variation, often inferred from data assembled over a relatively short period, seldom more than 50 years. Hügel & Davies (2020) argue that the scientific understanding of fine-scale processes at the local level that support or inhibit these responses has been limited, particularly for households in low-income settings such as immigrant farmworkers with strong social ties to their employers.

Household-level data enables regional-scale trends related to factors that inhibit or stimulate local-level adaptation to be more fully understood and considered in formulating locally derived intervention strategies to slow or reduce climate change impacts. Where the impacts on ecosystems and human communities have been studied, these analyses have commonly been primarily focused on relatively wealthy regions. The argument being that households in low- and middle-income settings are more vulnerable to local climate change impacts (Barnes et al., 2020).

Sub-Saharan African communities that rely primarily on rainfed agriculture, often combined with local livestock herding, have many risk factors, including poor soils, high population densities, high population growth rates, and reliance of a large share of the labor force on climatically sensitive agricultural employment. In addition, these are often the communities that have the fewest resources to respond to or build resilience to changing climatic conditions.

In Namibia as a country, and the Omusati region as an area of study, predictions about climate change show that increases in average temperatures in the central and northern areas of the

country might exceed the global mean, resulting in the rise of ground temperatures, an increase in the frequency and intensity of hot days and heat waves, as well as an increase in moisture stress (Mapani et al., 2023). To address the adverse impacts of climate change, livelihood systems are expected to adapt through the adoption of new strategies and livelihood options. These options may include changes in cropping practices, changes in the timing and methods of planting, and the adoption of more drought-resistant crops

2.2 Understanding Vulnerability and Resilience

Understanding vulnerability and resilience to climate change is important for adaptation planning and developing effective responses. However, these concepts are not static conditions but are dynamic and contingent upon both individual and community capacities to withstand, adapt to, and recover from the impacts of climate change. According to Joakim et al. (2021), vulnerability can be defined as the susceptibility of a system, community, or individual to harm, while resilience refers to the capacity to absorb shocks, recover, and adapt to changing conditions. Joakim et al. (2021) also note that vulnerability is shaped by both environmental and social stressors, which exacerbate existing inequalities and affect the distribution of climate risks across populations.

Current literature emphasizes the centrality of vulnerability and resilience in differentiating between the present and future burdens of climate change (Lanlan et al., 2024). Vulnerability often results from a combination of factors, including exposure to climate risks, sensitivity to those risks, and the capacity of individuals or systems to adapt. Furthermore, vulnerable communities often lack access to resources, social support networks, and technologies that could mitigate climate impacts. A deeper understanding of these vulnerabilities enables adaptation strategies that target the most at-risk individuals and groups within a community. The aim being to enhance their adaptive capacity, which is key to mitigating the negative impacts of climate change (Birkmann et al., 2022).

On the other hand, resilience describes a community's ability to strengthen its internal mechanisms and protect itself from external threats. While these two concepts are sometimes seen as distinct, many scholars, such as Birkmann et al. (2022), believe that vulnerability and resilience are interconnected and interdependent. Vulnerable populations may also demonstrate resilience in certain areas, as they develop localized coping mechanisms to address the risks they face. On the other hand, external threats like climate change can exacerbate vulnerability, weaken adaptive capacities, and make it harder for communities to maintain their resilience. The Adaptive Capacity Wheel of Analysis, introduced by Joakim et al. (2021), gives us a framework to

systematically assess these dynamics, help classify and analyze the vulnerability and resilience of different actors within a community. This analysis assists in identifying where external interventions may be most effective without assuming that communities have inherent power to withstand climate-induced changes on their own.

2.2.1 Conceptual Frameworks for Understanding Vulnerability and Resilience

Several conceptual frameworks have emerged in the literature to help scholars and practitioners understand vulnerability and resilience in the context of climate change. Vulnerability, as defined in the literature, refers to the degree of exposure to climate-related stress and the sensitivity of people and ecosystems to that stress (Schilling et al., 2020). This concept of vulnerability draws from the IPAT equation, which connects environmental impact with population, affluence, and technology. In the case of climate change, social vulnerability is often linked to factors like poverty, lack of infrastructure, and marginalization, which increase the risks communities face from climate hazards (Joakim et al., 2021). Table 2/.1 shows some of the farmer vulnerability areas in the Omusati region:

Table 2.1: Common vulnerability indicators for the Omusati region

	Hazard or issue	Justification
1	**Drought, low rainfall (including seasonal shifts in rainfall season)**	A common occurrence in north-central Namibia and a key issue affecting people's livelihoods and wellbeing. Increased water shortage associated with droughts, changes in precipitations and rainfall amounts directly affect agricultural yields and animal production.
2	**Limited knowledge about climate change (and adaptation strategies)**	There is a general lack of awareness about climate change and the risks it poses to the communities and their wellbeing.
3	**Limited access and uptake of meteorological data**	Relevant, timely and context specific meteorological information and advice do not reach farmers and communities in general. Both lack of understanding of the type of information and uncertainty on the information delivered affects uptake and increase sensitivity to climate impacts.
4	**Floods associated with heavy rainfall**	Floods occur in Onesi and affect people specifically those living in settlements along *oshana*. Floods not only spoil crops and lead to hunger, but also cause severe damage to infrastructure.
5	**Limited uptake of new agriculture practices and farming technologies**	There is a very low uptake of new technologies and new approaches of farming by the subsistence farmers. New technologies of farming are introduced by the central government and there seems to be no ownership by the local farmers e.g. preference on traditional Mahangu over new improved seeds such as Okashana.
6	**Poorly resourced agricultural extension services**	Insufficient number of extension officers.
7	**High temperatures**	Increased water shortages associated with higher temperatures directly affect agricultural yields and animal production.
8	**Cultural practices preventing the adoption of new practices**	There is a strong cultural prestige to have large number of herds which affects destocking as an option to reduce the impacts of drought. If one sells the stocks, one will feel less important in the society than if s/he have more.
9	**Lack of alternatives to agriculture based livelihoods**	Insufficient access to diversified and resilient livelihood systems is prevalent in Omusati Region. Climate impacts put stress on the majority of the population, who cannot find alternative employment options to farming.
10	**Limited marketing and selling of animals**	The lack of marketing of livestock is driven in part by strong cultural beliefs, economic factors and the lack of

(CARIAA/ASSA, 2016)

Resilience has been widely explored through the lens of ecological processes. According to the Panarchy theory, as outlined by Fahad & Wang (2020), resilience is part of a non-linear adaptive cycle. In this model, ecosystems and communities can undergo phases of growth, accumulation, restructuring, and renewal. Resilience is built through adaptive learning and the development of novel strategies, particularly during periods of change. Schilling et al. (2020) propose that the work on common-pool resource management further emphasizes the social dimensions of resilience. Communities managing shared resources, such as water or land, must navigate complex social-ecological interactions to adapt to climate stressors (Schilling et al., 2020). By focusing on how both social and ecological systems respond to external pressures, these frameworks provide valuable insights into the factors that enhance or weaken resilience.

2.2.2 Factors Influencing Vulnerability and Resilience in Rural Communities

In rural community settings, there are several key factors that influence both vulnerability and resilience. Having access to reliable networks and role players, such as local extension officers or community leaders, is a significant determinant of resilience. According to Selemani (2020) these individuals provide critical support in solving problems related to farming, resource management, and adapting to climate impacts. Additionally, access to and control over resources like water, land, and agricultural technologies play a central role in shaping a community's adaptive capacity. Communities with secure access to these resources are better equipped to implement climate adaptation strategies, such as switching to drought-resistant crops or adopting water conservation techniques (Pearson et al., 2023).

Another critical factor in vulnerability and resilience is the preservation and use of Indigenous Knowledge Systems (IKS). Rural communities often rely on traditional knowledge about the environment, weather patterns, and resource management to adapt to climate variability. However, the erosion of these systems due to modernization, loss of respect for local knowledge, and lack of documentation is a significant vulnerability for many communities (Fernández-Llamazares et al., 2021). Protecting and integrating IKS into climate adaptation strategies can provide valuable insights that complement Western scientific approaches and strengthen community resilience.

Learning processes within and across communities are also crucial. Selemani (2020) identifies a lack of honest engagement between actors, such as government officials, NGOs, and local communities, as a hindrance to adaptation efforts. For example, he notes that co-managed projects may fail if participants do not fully understand their roles or fail to share critical knowledge. There should be an effort to ensure that all actors engage in meaningful dialogue and learn from

one another can help create more robust adaptation strategies. Furthermore, sustainable agricultural practices that incorporate both modern innovations and traditional techniques can improve resilience by promoting soil health, water conservation, and biodiversity, which are essential for long-term sustainability in the face of climate change. If these factors are addressed, rural communities can enhance their resilience while reducing vulnerabilities. However, targeted interventions are necessary to ensure that marginalized populations within these communities, who are often the most vulnerable, receive the support they need to adapt to climate change effectively.

2.3 Community-Based Approaches to Climate Change Adaptation

Community-based approaches to adaptation to climate change have been recently identified as a key strategy in developing sustainable, equitable, and effective responses to the impacts of climate change. These approaches emphasize public participation, which integrates local knowledge and the experiences of those most affected by climate variability and change. They are often framed within broader processes of Integrated Development Planning (IDP), which aim to foster decentralized governance and accommodate the varying capacities and complexities of communities across the globe. Pearson et al. (2023) note that local communities, particularly in rural areas of developing countries, often lack the resources or infrastructure needed to independently cope with climate change. Engaging communities directly in adaptation planning ensures that solutions are context-specific, culturally appropriate, and reflective of the diverse needs and capacities of local populations.

Community-based approaches also provide a necessary counterbalance to top-down, one-size-fits-all adaptation measures that are often tested at the global level without considering local contexts. Fahad and Wang (2020) argue that such uniform solutions risk leading to maladaptation, where interventions may inadvertently increase vulnerability rather than reduce it. This underscores the importance of knowledge sharing between local communities, stakeholders, and decision-makers across multiple governance levels. By creating spaces for dialogue and exchange, community-based approaches can ensure that adaptation strategies are informed by the lived experiences of those who are on the frontlines of climate change (Selemani, 2020). Facilitating participation by community members helps ensure that the governance transformations necessary to address the complex environmental, social, and economic challenges posed by climate change are both inclusive and equitable.

Public participation in climate decision-making complements global and national policy formulation and implementation efforts. It enables a bottom-up flow of information that aligns national goals with local needs. Joakim et al. (2021) note that community-based approaches, through participatory methodologies, bring together voices from diverse sectors, allowing for a more holistic understanding of climate impacts and ensuring that policy interventions are responsive to specific local realities. Governments play a critical role in creating the enabling environments necessary for such public participation, fostering collaboration through partnerships that promote Integrated Development Planning. According to Lanlan et al. (2024), when governments collaborate with local communities and organizations, they enhance the effectiveness of climate adaptation strategies and build the capacity necessary for long-term resilience.

2.3.1 Definition and Significance of Community-Based Adaptation

Community-Based Adaptation (CBA) is a locally driven process that seeks to reduce vulnerability and build resilience to climate change by directly engaging the communities most affected by climate impacts. According to Fernández-Llamazares et al. (2021), CBA initiatives focus on the inclusion of community-based organizations (CBOs) or local stakeholders in the design, planning, and implementation of climate adaptation initiatives. This approach acknowledges that communities possess valuable traditional knowledge and skills that can significantly contribute to the development of more effective and context-appropriate adaptation strategies. As opposed to top-down models, which often impose external solutions without considering local realities, CBA initiatives are built on the premise that those living in vulnerable areas are best equipped to understand their own needs and priorities in adapting to climate change.

The integration of traditional knowledge with modern adaptation strategies is a key strength of the CBA approach. Many rural communities, particularly in developing countries, rely heavily on natural resources for their livelihoods, making them especially vulnerable to changes in climate (Selemani, 2020). By merging indigenous practices with contemporary scientific knowledge, CBA initiatives create solutions that are both culturally relevant and scientifically sound. Pearson et al. (2023) argue that most CBA programs focus on supporting the most vulnerable and disadvantaged groups within these communities, who are often disproportionately affected by climate change due to limited access to resources, information, and formal support systems.

A core element of CBA is its focus on poverty reduction as part of its adaptation efforts. Many vulnerable communities face socio-economic challenges that exacerbate their exposure to climate risks. CBA strategies, therefore, aim not only to address the immediate impacts of climate

change but also to tackle underlying socio-economic inequalities. This dual focus helps build resilience by empowering communities to better cope with both environmental and economic pressures (Fahad & Wang, 2020). By addressing issues such as income inequality, access to resources, and social exclusion, CBA initiatives work to create more robust and adaptable communities that are better prepared to face the uncertainties of climate change.

One of the key challenges in climate adaptation is that climate change is a global phenomenon, but its impacts are experienced locally. National and international climate policies often fail to account for the specific contexts in which local communities operate. As highlighted by Fernández-Llamazares et al. (2021), centralized climate policies can overlook the nuanced needs of rural or marginalized communities, leading to a disconnect between policy and practice. CBA addresses this gap by ensuring that local perspectives are incorporated into broader adaptation initiatives, allowing for a more localized and targeted response to climate change.

CBA initiatives are also dynamic and continuous, reflecting the evolving nature of climate risks. As communities engage in these processes, they not only adapt to current conditions but also build the capacity to respond to future challenges. This ongoing process of learning and adaptation is critical for ensuring long-term sustainability (Joakim et al., 2021). It also facilitates the transfer of knowledge from local communities to higher levels of governance, ensuring that local insights are integrated into broader policy frameworks.

Community-Based Adaptation is a vital approach to climate change adaptation, particularly for rural and vulnerable populations. By engaging communities directly in the decision-making process, CBA promotes solutions that are tailored to specific local conditions and challenges. It also strengthens resilience by addressing both environmental and socio-economic vulnerabilities, helping to create more equitable and sustainable adaptation outcomes. As climate change continues to impact communities worldwide, CBA offers a pathway to building more inclusive, context-driven, and resilient societies.

2.3.2 Community Involvement in Climate Change Adaptation

Research on climate change adaptation is now increasingly emphasizing the need for greater community involvement, particularly as previous interventions are often designed and implemented through top-down approaches. A growing body of literature advocates for integrating local knowledge, practices, and institutions into adaptation strategies, as these are often more effective in managing the dynamic and unpredictable impacts of climate change. According to Fernández-Llamazares et al. (2021), indigenous knowledge systems, passed down through

generations, are critical for managing natural resources and responding to environmental changes. Despite their significant contributions, these knowledge systems are frequently incorporated into adaptation efforts within the framework of dominant Western scientific paradigms. This can sometimes undermine the social and cultural dimensions of indigenous practices, reducing their effectiveness in addressing the complexities of climate change.

Researchers have raised concerns about the limited reflection of community perspectives in current institutional adaptation efforts, particularly in rural areas where livelihoods are most vulnerable to climate impacts (Selemani, 2020). These communities, which often rely heavily on indigenous knowledge practices, are not always adequately represented in the decision-making processes of the institutions responsible for managing natural resources. This disconnect can lead to adaptation strategies that are misaligned with the needs and capacities of local populations, further worsening their vulnerability. Fahad and Wang (2020) argue that adaptation strategies designed without meaningful community participation are less likely to succeed in building long-term resilience, as they fail to account for local socio-cultural contexts and resource management practices.

The participation of stakeholders, including local authorities, community-based organizations, and civil society, is essential for ensuring that adaptation policies are both effective and equitable. By involving diverse stakeholders in the policy development process, communities can proactively shape adaptation strategies, aligning them with local priorities and capacities. This participatory approach empowers communities to take ownership of adaptation efforts, positioning them as active drivers of change rather than passive recipients of externally imposed interventions (Lanlan et al., 2024). Pearson et al. (2023) highlight the importance of local institutions, which often serve as the primary interface between national policies and community-level implementation. These institutions play a crucial role in facilitating the flow of information, resources, and support needed to enhance adaptive capacity.

In this context, the ability of local governments, organizations, and community structures to make informed decisions is vital for addressing the increasingly complex challenges posed by climate change. As climate change intersects with other social, economic, and ecological stressors, the capacity of local institutions to respond effectively becomes even more critical. Joakim et al. (2021) emphasize the building of institutional capacity of local actors, which not only strengthens their ability to manage climate risks but also enhances their overall resilience to other development challenges, such as poverty, inequality, and environmental degradation.

2.3.3 Traditional vs. Modern Adaptation Strategies

The debate between traditional and modern adaptation strategies mirrors the broader tension between indigenous knowledge systems and contemporary scientific approaches in addressing climate change. Traditional adaptation strategies are deeply rooted in the cultural and ecological knowledge of local communities, particularly in rural and indigenous populations. According to Schilling et al. (2020), these strategies often involve practices that have been refined over centuries to cope with environmental variability, such as the use of drought-resistant crops, water conservation techniques, and communal resource management. These traditional methods are highly adaptive to specific local conditions, making them particularly relevant in the context of climate change, where localized impacts require localized responses.

Modern adaptation strategies, which are often driven by scientific research and technological innovation, tend to dominate national and international climate policy. These strategies include the development of new agricultural technologies, infrastructure projects, and market-based mechanisms, such as carbon trading (Birkmann et al., 2022). While modern approaches can provide valuable tools for climate adaptation, they are not always compatible with traditional practices. Selemani (2020) points out that in some cases, the introduction of modern technologies may disrupt local ecosystems or undermine the social cohesion that underpins traditional resource management systems.

A case in point is that the introduction of modern irrigation systems might increase agricultural productivity but could also lead to the depletion of water resources that are vital for the survival of local ecosystems. Similarly, market-based mechanisms for climate adaptation may fail to benefit marginalized communities that lack access to financial resources or technical expertise. Fahad and Wang (2020) argue that the imposition of such strategies without considering local contexts can lead to maladaptation, where the very efforts intended to mitigate climate impacts end up increasing vulnerability.

Rather than viewing traditional and modern adaptation strategies as mutually exclusive, there is a growing recognition of the need for hybrid approaches that integrate the strengths of both systems. This involves leveraging scientific innovation and technological advancements while also respecting and incorporating indigenous knowledge and practices (Fernández-Llamazares et al., 2021). By combining traditional and modern approaches, communities can enhance their resilience to climate change in ways that are both contextually appropriate and sustainable. This integrated approach is particularly important for rural and indigenous communities, which are

often the most vulnerable to climate impacts and yet possess valuable knowledge and practices that can contribute to effective adaptation strategies.

The involvement of communities in adaptation of climate change is critical to ensuring that adaptation strategies are both effective and equitable. By integrating traditional knowledge with modern scientific approaches and by fostering meaningful participation from diverse stakeholders, climate adaptation efforts can be better aligned with the needs and capacities of those most affected by climate change. As climate impacts continue to intensify, the role of local communities in shaping adaptation strategies will become increasingly important in building resilient and sustainable futures.

2.4 Governance and Climate Change

Governance plays a fundamental role in climate change adaptation, particularly through the actions of local governments and their ability to integrate traditional knowledge into formal decision-making structures. Local governance is essential for creating effective climate adaptation strategies that are context-specific, addressing both the unique environmental conditions and the socio-cultural practices of local communities. However, challenges arise in integrating traditional knowledge with modern governance systems, necessitating policy reforms to ensure more inclusive, adaptive, and sustainable governance frameworks.

2.4.1 The Role of Local Governance in Supporting Adaptation Efforts

Local governance is critical in facilitating climate adaptation, especially in the implementation of strategies that are tailored to local contexts and needs. The primary role of local governance is to promote and incorporate culturally specific perspectives, technologies, and practices, such as traditional crop variety development, indigenous early warning systems for climate variability, alternative livelihood strategies, and community-based water management systems (Joakim et al., 2021). These localized approaches to climate adaptation are often rooted in centuries of indigenous knowledge and practices, which have been proven effective in managing environmental changes and resource use in rural and indigenous communities.

According to Birkmann et al. (2022), the capacity of local governments to manage climate adaptation efforts depends significantly on their ability to collaborate with central governments, access financial and technical resources, and exercise decision-making authority. The decentralization of governance structures, which grants local institutions greater autonomy, is often cited as a key factor in enhancing the adaptive capacity of communities. This approach allows local authorities to tailor adaptation measures to the specific vulnerabilities and strengths

of their communities. However, the success of such decentralization efforts largely depends on the extent to which local governments can secure funding and expertise from national and international bodies (Schilling et al., 2020). Community-based water management practices, which are critical in regions facing water scarcity due to climate change, require significant technical support and investment.

Local governments also play an important role in mitigating conflicts over natural resources, which are likely to become more frequent and intense as climate change exacerbates resource scarcity. In areas where communities rely on communal land and water resources, effective local governance is essential to mediating disputes and ensuring equitable access to these resources. Furthermore, local institutions, such as community-managed protected areas and forest management groups, have been shown to be more effective in conserving biodiversity and managing natural resources than centralized, politically influenced agencies (Fahad and Wang, 2020). These locally managed institutions are often better equipped to respond to the needs and priorities of the local population, providing livelihood options that are compatible with conservation goals.

Despite their importance, local governance structures often face significant challenges in executing their responsibilities. Lanlan et al., (2024) adds that these challenges are particularly pronounced in developing countries, where local governments may lack the financial and administrative capacity to implement effective climate adaptation measures. Additionally, the political influence on conservation policies at the national level can undermine the efforts of local institutions, leading to conflicts between conservation goals and the livelihood needs of local communities. As a result, traditional conservation strategies, which often exclude local populations from decision-making processes, have been widely criticized for failing to meet the needs of those most affected by climate change (Fernández-Llamazares et al., 2021).

2.4.2 Challenges in Integrating Traditional Knowledge into Formal Governance Structures

One of the key challenges in climate change governance is the integration of traditional knowledge into formal governance structures. Selemani (2020) points out that indigenous and local knowledge systems, which have developed over centuries, offer valuable insights into sustainable resource management and climate adaptation. However, these knowledge systems are often marginalized or ignored in formal governance frameworks, which tend to prioritize Western scientific approaches. This exclusion not only undermines the effectiveness of adaptation

strategies but also disempowers local communities, whose knowledge and practices are essential for managing the complex socio-environmental impacts of climate change.

Integrating traditional knowledge into formal governance structures requires a fundamental shift in how knowledge is valued and utilized in decision-making processes. Current governance models often fail to recognize the legitimacy of indigenous knowledge, treating it as secondary to scientific data. This can lead to the imposition of adaptation measures that are ill-suited to local contexts, resulting in maladaptation (Pearson et al., 2023). For instance, modern agricultural technologies promoted by national governments may not be compatible with the traditional farming practices of indigenous communities, leading to soil degradation and loss of biodiversity.

Moreover, there are institutional barriers to the integration of traditional knowledge into governance systems. Many local governance structures are not designed to accommodate the participatory processes necessary for incorporating indigenous perspectives into policy-making. This is compounded by a lack of political will at higher levels of government, where decision-makers may be more focused on short-term economic gains than on long-term sustainability and resilience. As a result, the valuable contributions of traditional knowledge are often overlooked in favor of top-down, technocratic solutions (Schilling et al., 2020).

2.4.3 Policy Recommendations and Future Directions

To address these challenges, there is a need for policy reforms that promote the integration of traditional knowledge into formal governance frameworks. Governments must first recognize the value of indigenous knowledge systems and actively seek to incorporate them into climate adaptation planning and implementation. This can be achieved through participatory governance models that give local communities a voice in decision-making processes, ensuring that adaptation strategies are context-specific and culturally appropriate (Joakim et al., 2021).

Additionally, capacity-building efforts are needed to strengthen the ability of local governments and institutions to manage climate adaptation effectively. This includes providing financial resources, technical expertise, and training to local authorities, enabling them to implement adaptation measures that are responsive to the needs and priorities of their communities. Birkmann et al., (2022) suggest that international organizations and donors can play a crucial role in supporting these efforts by providing funding and facilitating knowledge exchange between local, national, and global actors.

There is also a need for greater collaboration between traditional knowledge holders and scientific communities. By building partnerships between indigenous communities, researchers, and

policymakers, it is possible to develop hybrid adaptation strategies that draw on the strengths of both traditional and scientific knowledge systems. Such collaborations can lead to more effective and sustainable adaptation outcomes, particularly in rural and indigenous communities that are most vulnerable to the impacts of climate change (Fernández-Llamazares et al., 2021). Local governance plays a critical role in supporting climate adaptation efforts, particularly through the integration of traditional knowledge into formal governance structures. By strengthening the capacity of local institutions and promoting more inclusive governance models, it is possible to enhance the resilience of communities to the growing challenges posed by climate change.

2.5 Climate Change Impacts on Agriculture and Livelihoods

Agriculture, as one of the most climate-sensitive sectors, faces significant risks from the ongoing variability, extremes, and changes in climate. Recent studies highlight the extreme vulnerability of agriculture to climate change, particularly in tropical and subtropical regions where many developing nations rely on farming as the cornerstone of their economies. The critical role of agriculture in ensuring food security for billions of people worldwide cannot be overstated, as it provides the primary source of livelihoods for rural populations and is deeply intertwined with economic stability (Nelson et al., 2021).

For countries in the Global South, the challenge of feeding a rapidly growing population is becoming increasingly daunting in the face of degrading climatic conditions. Changes in precipitation patterns, temperature extremes, and the increased frequency of droughts and floods are already impacting crop yields and threatening the viability of small-scale farming. FAO (2022) notices that the traditional comparative advantage of many developing countries, which have been based on inexpensive agricultural labor, is rapidly diminishing as climate stressors reduce productivity and undermine the sustainability of agricultural livelihoods.

Ensuring global and regional food security remains a top priority for international organizations and governments all over the world. At both national and household levels, the ability to respond effectively to food shortages and famines is crucial, with agricultural systems and farming practices forming the backbone of resilience strategies (IPCC, 2022). However, agriculture is not just about food production but also serves as a buffer for economic and social stress, providing a safety net for rural populations in times of crisis.

In this context, climate change presents an immense challenge for nations heavily reliant on agriculture. The rural populations of these countries, already facing development hurdles, are now grappling with increased climate risks that threaten to derail their progress toward achieving

sustainable development goals (SDGs). According to UNDP (2022), the increasing strain on non-agricultural sectors to compensate for the decline in agricultural output due to climate impacts creates a cascading effect, exacerbating social and economic stress. To counter these risks and ensure sustainable development, it is imperative to develop strategies that enable both agricultural and non-agricultural sectors to adapt to reduced climate risks at the regional, national, and local levels (FAO, 2022).

Smallholder farmers are at the forefront of this adaptation process. As the primary managers of weather-related risks, farmers possess a wealth of local knowledge and experience, positioning them as critical agents of change in the fight against climate-induced agricultural decline. However, to fully leverage their potential, Khan et al (2022) advise that farmers need support from a wide range of stakeholders, including researchers, agricultural extension agents, and policy implementers. The strengthening of farmer organizations is vital in this context, as these groups provide a platform for collective action, risk management, and the dissemination of climate-smart practices. FAO (2022) identifies improved risk management and capacity-building efforts as the essential ingredients for increasing resilience and ensuring that farming communities can sustainably adapt to the new climate realities.

2.5.1 Climate Change Impacts on Agriculture

The impacts of climate change on agriculture are diverse and region-specific but broadly include reduced crop yields, altered growing seasons, and increased susceptibility to pests and diseases. In many regions, rising temperatures and shifting rainfall patterns have shortened the growing periods for staple crops such as maize, wheat, and rice, threatening food production and increasing the risk of hunger (Lobell & Gourdji, 2012). Droughts, which are becoming more frequent and severe according to Nelson et al. (2021), are particularly damaging in rain-fed agricultural systems, leading to significant crop failures and reduced water availability for irrigation. In contrast, some areas may experience increased rainfall, leading to floods that destroy crops and erode soil, further compromising agricultural productivity.

In regions such as Sub-Saharan Africa, where agriculture is the dominant livelihood for rural populations, the impacts of climate change are already evident. For example, studies by Schlenker & Lobell, (2010) have shown that by 2050, crop yields in parts of Africa could decline by up to 30%, threatening the livelihoods of millions of smallholder farmers and heightening food insecurity. Furthermore, changing temperatures can shift the geographic range of crops, forcing farmers to adapt to new crop varieties or abandon farming altogether in certain areas. These changes also have broader economic implications, as reduced agricultural output can lead to

increased food prices, inflation, and economic instability, particularly in developing countries (FAO, 2022).

2.5.2 Food Security and Climate Change

Food security, defined as the availability, accessibility, utilization, and stability of food supplies, is increasingly threatened by climate change. IPCC (2022) points out that the ability of agricultural systems to produce sufficient food is jeopardized by the growing unpredictability of weather patterns, leading to fluctuations in food production that disrupt supply chains and exacerbate hunger and malnutrition, particularly in vulnerable regions. The most affected populations are those in rural areas, where agriculture is the primary source of income and subsistence.

In developing countries, where food systems are less resilient to shocks, the impacts of climate change on food security are most severe. For example, in Southern Africa, where rainfall variability is high, the combination of droughts and floods has led to recurrent food crises that disproportionately affect the poorest households (FAO, 2022). Moreover, the increasing frequency of extreme weather events has undermined the stability of food supplies, making it harder for governments and international organizations to respond effectively to food shortages and famines.

2.5.3 Vulnerability of Smallholder Farmers

Smallholder farmers, who produce a significant portion of the world's food, are among the most vulnerable to the impacts of climate change. These farmers typically operate on marginal lands, with limited access to resources such as water, seeds, and technology. They are also highly dependent on rainfall for crop production, making them particularly susceptible to changes in precipitation patterns (Khan et al., 2022). Furthermore, smallholder farmers often lack access to formal markets, insurance, and credit, which limits their ability to recover from climate-related losses and invest in adaptation measures.

In Sub-Saharan Africa and South Asia, smallholder farmers are especially vulnerable due to the high prevalence of poverty and the reliance on agriculture for both income and food. Climate change worsens existing challenges such as soil degradation, water scarcity, and low productivity, making it even harder for these farmers to achieve food security and improve their livelihoods (Schlenker & Lobell, 2010). FAO (2022) notes that without targeted interventions, the vulnerability of smallholder farmers is likely to increase, leading to greater food insecurity and economic instability in these regions.

2.5.4 Adaptation Strategies for Agricultural Communities

To mitigate the impacts of climate change on agriculture, a range of adaptation strategies must be implemented. Nelson et al. (2021) identify these strategies to include the adoption of climate-smart agricultural practices, such as conservation agriculture, agroforestry, and the use of drought-resistant crop varieties. In addition, improving water management through techniques such as rainwater harvesting, drip irrigation, and the construction of small-scale reservoirs can help farmers cope with water scarcity and reduce the risk of crop failure during droughts (FAO, 2022).

Strengthening the capacity of farmers to adapt to climate change requires investment in agricultural research and extension services that provide farmers with the knowledge and tools they need to implement sustainable practices. Governments and international organizations must also prioritize the development of early warning systems and weather forecasting tools that enable farmers to plan for and respond to extreme weather events (Khan et al., 2022). Schlenker & Lobell (2010) advise that enhancing access to financial services, such as crop insurance and credit, is critical for enabling smallholder farmers to invest in climate-resilient technologies and recover from climate-related losses.

2.6 Adaptive Capacity and its Determinants

2.6.1 Concept of Adaptive Capacity

Brooks et al. (2005) define adaptive capacity as a community's or individual's ability to respond to, manage, and reduce the adverse impacts of climate change, ensuring resilience in social, economic, and environmental contexts. Defined by the IPCC (2022), adaptive capacity involves modifying practices, systems, or structures to mitigate the negative impacts of climate change and harness potential benefits. Adaptive capacity is integral to resilience, as it enables communities, particularly vulnerable and agriculture-dependent ones, to anticipate and recover from climatic stresses, thereby ensuring sustainable livelihoods (Nelson et al., 2007). For communal farmers, adaptive capacity involves not only responding to extreme weather events but also adjusting their agricultural practices to sustain productivity under shifting climatic conditions.

2.6.2 Factors Influencing Adaptive Capacity

Adaptive capacity is determined by multiple interrelated factors, with variations observed across different social, economic, and institutional contexts:

- **Social Factors:** Social networks, access to education, and local knowledge significantly enhance adaptive capacity. Adger et al. (2009) identify that strong community ties facilitate knowledge sharing and collective responses to climatic events, while education provides the foundation for understanding climate risks and adopting appropriate adaptation measures. Local knowledge and cultural practices also shape farmers' decisions, often aiding in the development of climate-resilient agricultural practices (Pelling & High, 2005).
- **Economic Factors:** Economic resources, including access to credit, savings, and diversified income sources, are essential for adaptation. Wealthier farmers generally exhibit greater adaptive capacity due to their ability to invest in advanced technologies, climate-resilient crop varieties, and protective infrastructure (Smit & Pilifosova, 2003). Additionally, diversification, both in crop production and income, mitigates risks associated with climate variability, providing alternative means of income during adverse conditions (Deressa et al., 2009).
- **Institutional Factors:** Adaptive capacity is strengthened by supportive institutions, including governmental policies, agricultural extension services, and local organizations that provide critical resources and information to farmers. Agrawal et al., (2008) points that effective institutional frameworks ensure timely access to resources, such as weather forecasts, financial services, and agricultural subsidies, enabling farmers to make informed and resilient decisions. Policies fostering climate-smart agriculture, for example, create an enabling environment for farmers to adopt sustainable practices (Nelson et al., 2021).

2.6.3 Measurement and Assessment of Adaptive Capacity

Measuring adaptive capacity is challenging due to its multi-dimensional nature. However, various frameworks assess this concept through indicators related to resource availability, institutional support, and socio-economic conditions (Adger et al., 2009). Key methods include vulnerability assessments, which analyze exposure, sensitivity, and adaptive capacity to climate risks, and index-based approaches that quantify adaptive capacity through socio-economic and environmental indicators. These measurements allow researchers and policymakers to identify areas needing targeted interventions, thereby strengthening community resilience (IPCC, 2022).

2.7 Agricultural Adaptation Strategies in Namibia

2.7.1 Impact of Climate Change on Agriculture in Namibia and Omusati

Namibia's agriculture sector is highly susceptible to climate change, as its arid to semi-arid climate predisposes it to variable rainfall, high temperatures, and recurrent droughts. These climatic stressors threaten crop yields, soil quality, and water resources, compromising food security and livelihoods for Namibian farmers, particularly in communal and rural areas (MET, 2019). Studies indicate that erratic weather patterns reduce harvest quantities, impacting staple crops such as maize and millet, which are essential for rural communities' subsistence and income (FAO, 2022).

In the Omusati region, situated in north-central Namibia, the impact of climate change is particularly severe due to its high dependency on rain-fed agriculture and communal farming systems. The region experiences increasingly erratic rainfall patterns and prolonged drought periods, resulting in crop failures and water scarcity that threaten both food security and economic stability for local farmers. Farmers in Omusati primarily grow millet, sorghum, and maize, which are highly sensitive to water availability. MET (2019) identifies drought conditions and irregular rain as having led to significant declines in crop productivity, forcing some households to reduce the area they cultivate or abandon agriculture altogether in extremely dry seasons. The limited irrigation infrastructure in Omusati exacerbates these challenges, as most farmers rely on seasonal rains to support their crops. This dependence on rainfall renders the region especially vulnerable to climate variability and increases the risk of food insecurity, particularly among low-income and resource-poor farming households (FAO, 2022).

Additionally, climate change has disrupted traditional agricultural practices in Omusati, as rising temperatures and shifting seasonal patterns complicate the timing of planting and harvesting. Higher temperatures accelerate soil evaporation rates, reducing soil moisture and limiting the effectiveness of rains that does fall. This, combined with frequent droughts, has prompted soil degradation and increased erosion, further diminishing the land's productivity. For pastoral communities, these conditions also pose challenges to livestock production, as prolonged dry spells reduce grazing lands and water sources, leading to lower animal health and increased mortality rates (MET, 2019). Climate-induced shifts have thus placed immense stress on communal farmers in Omusati, highlighting the need for targeted adaptation strategies such as water-saving technologies, soil conservation practices, and drought-resistant crops to build resilience and sustain livelihoods in the face of climate change.

2.7.2 Agricultural Adaptation Techniques in Rural Communities

To address climate variability, Namibian farmers employ various adaptation strategies tailored to their environmental conditions. Common practices include:

- **Intercropping and Crop Diversification:** Intercropping, or growing multiple crops in the same field, reduces the risk of complete crop failure due to adverse weather. By diversifying crops, farmers can protect themselves against losses while also improving soil health and productivity (Deressa et al., 2009).
- **Drought-Resistant Crop Varieties:** Drought-resistant crops, such as pearl millet, are increasingly adopted as they require less water and are better suited to Namibia's dry conditions. These crops reduce dependency on rainfall, providing a more reliable food source even in drought years (MET, 2019).
- **Improved Water Management:** Farmers utilize water conservation techniques like rainwater harvesting and small-scale irrigation to optimize limited water resources. These methods are crucial in arid regions, allowing farmers to sustain crop production during dry periods and manage water scarcity (FAO, 2022).

2.8 Case Studies of Community-Based Adaptation in Southern Africa

2.8.1 Overview of Community-Based Adaptation Initiatives in Southern Africa

Southern African countries, sharing similar climate risks, have implemented various community-based adaptation (CBA) initiatives. CBA empowers communities to develop and implement strategies that reflect their unique needs, local knowledge, and capacities, thereby promoting resilience to climate change. Stringer et al. (2009) argue that programs such as the Climate Adaptation for Rural Livelihoods (CARL) and the Climate Resilient Infrastructure Development Facility (CRIDF) work with communities to enhance water security, agricultural productivity, and ecosystem health.

2.8.2 Lessons Learned from Successful Adaptation Projects

Successful CBA initiatives in Southern Africa reveal the importance of integrating local knowledge, fostering community ownership, and ensuring access to resources. Projects that engage local stakeholders and emphasize community-led planning are more sustainable, as they build trust and enable communities to independently manage climate risks (Reid and Huq, 2014). FAO

(2022) identifies projects in Mozambique and Zimbabwe that have demonstrated that participatory approaches, coupled with capacity building, yield positive adaptation outcomes.

2.8.3 Challenges and Limitations of Community-Based Adaptation Initiatives

Despite their successes, CBA initiatives face challenges, including limited financial resources, insufficient institutional support, and the need for technical expertise. The dependency on external funding can restrict project sustainability, while inadequate policy frameworks may impede the implementation of locally driven adaptation actions (Pelling and High, 2005). Furthermore, scaling up successful CBA models requires addressing systemic issues, such as land tenure insecurity and inadequate market access (Reid and Huq, 2014).

2.9 Research Gaps and Future Directions

2.9.1 Identification of Research Gaps in Community-Based Adaptation Literature

Although CBA has gained traction, notable research gaps persist. First, there is limited empirical data on the long-term impacts of CBA initiatives, particularly on food security and livelihood sustainability in communal settings. Additionally, research focusing on gendered impacts of climate adaptation remains sparse, as women often face unique vulnerabilities in rural communities (Stringer et al., 2009). There is also a need for more studies on the economic viability of CBA initiatives in diverse socio-ecological contexts (Agrawal et al., 2008).

2.9.2 Future Research Directions for Improving Adaptation Outcomes

Future research should address these gaps by examining the long-term resilience of CBA strategies and their effectiveness in reducing vulnerability among marginalized groups. There is also a need to explore innovative funding mechanisms for sustaining adaptation projects, as well as to assess the integration of indigenous knowledge with modern adaptation practices. Pelling and High (2005) further argue that research should focus on identifying metrics for evaluating the success of CBA initiatives to enhance their scalability and impact on food security and livelihoods.

2.10. Conclusion

In conclusion, climate change poses a significant threat to agriculture-dependent communities, particularly in Southern Africa, where vulnerability is heightened by socio-economic challenges. Building adaptive capacity, promoting resilient agricultural practices, and fostering community-based adaptation are essential for ensuring the sustainability of rural livelihoods. Chapter 3 will

delve into the methodology used in this study to assess adaptive capacity and climate resilience among communal farmers, highlighting the research approach, data collection methods, and analytical frameworks employed.

Chapter 3: Methodology

3.1 Introduction

This chapter provides a comprehensive overview of the methodology employed in this study to investigate community-based responses and adaptations to climate change in the Omusati Region, Namibia. The chapter describes the study area, outlining both its physical and socio-economic characteristics. This is followed by a discussion of research design, sampling methods, data collection tools, variables, and data analysis techniques used. The chapter also addresses ethical considerations and concludes with a summary of the methodological approach, laying the groundwork for presenting research findings.

3.2 Study Area Description

The Omusati Region, situated in northern Namibia along the country's border with Angola, serves as a prime location for investigating the impacts of climate change on communal farming and community-based adaptation strategies. Omusati is one of Namibia's most populated regions, ranked third in terms of population density. According to the Namibian Statistics Agency (NSA, 2023), the Omusati Region recorded a total population of 316,671, with 169,406 females and 147,265 males. The region contains 46,698 households, averaging approximately 5.2 persons per household. This household structure is typical of Northern Namibia's Communal Areas, where extended family arrangements and multi-generational households are prevalent. Omusati's predominant reliance on subsistence farming, with over 70% of its population dependent on agriculture, accentuates the importance of effective adaptation strategies in the face of climate variability and environmental pressures (NSA, 2023).

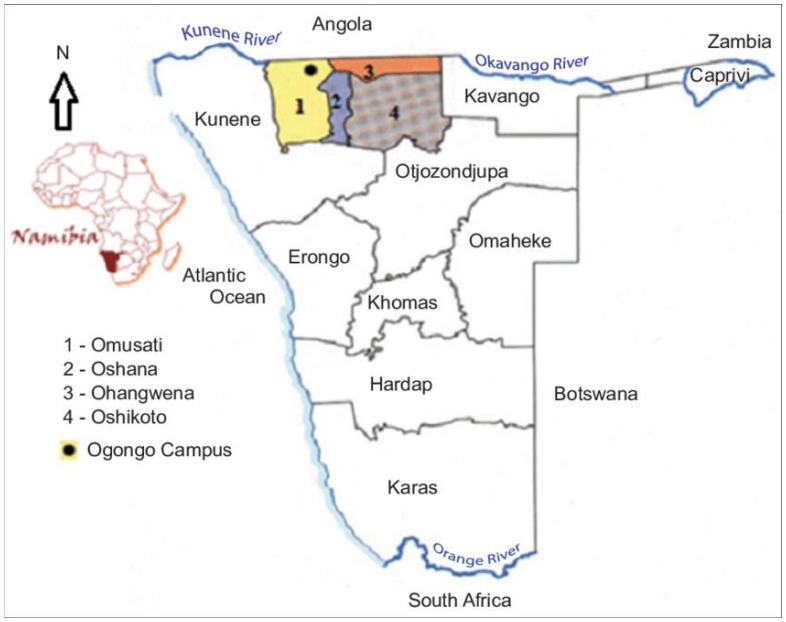
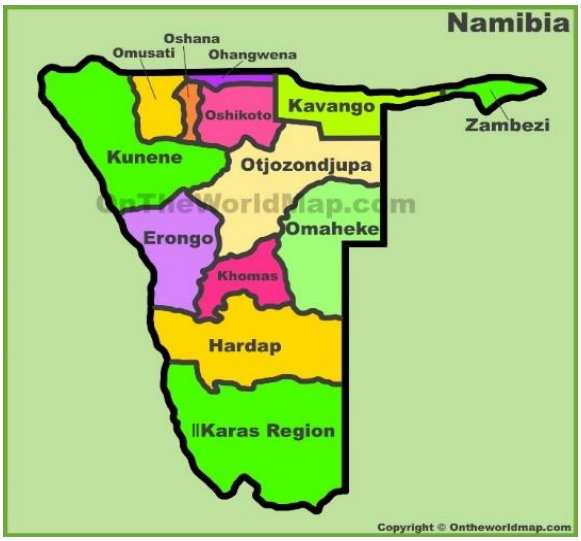


Figure 3.1: *Omusati Location (Microsoft Bing)*

3.2.1 Geographical and Biophysical Characteristics

Namibia's demographic distribution reflects diverse population densities across its regions, influenced by geographical and biophysical factors. The Khomas region, home to the capital Windhoek, has the highest population (342,141), showcasing urban concentration and economic opportunities in the capital. Following Khomas, the northern regions, including Ohangwena (245,446), Omusati (243,166), and Kavango (223,352), have substantial populations. These areas are generally more fertile and support agriculture, which sustains the livelihood of many rural communities.

In contrast, regions like Hardap (79,507), Karas (77,421), and Kunene (86,856) have lower populations, partly due to their arid climates and less favorable conditions for agriculture. Coastal regions like Erongo (150,809) have moderate populations due to economic activities such as mining and tourism centered around towns like Swakopmund and Walvis Bay. This distribution highlights the concentration of people in urban and agriculturally viable regions, while more arid, less fertile regions remain sparsely populated, reflecting how Namibia's physical environment shapes settlement patterns.



COUNTRY POPULATION DISTRIBUTION	
Namibia	2113077
Caprivi	90596
Erongo	150809
Hardap	79507
Karas	77421
Kavango	223352
Khomas	342141
Kunene	86856
Ohangwena	245446
Omaheke	71233
Omusati	243166
Oshana	176674
Oshikoto	181973
Otjozondjupa	143903

Figure 3.2: *Namibia's demographic information (NSA, 2011)*

3.2.2 Climate conditions in Namibia

Namibia's climatic conditions vary significantly across regions, reflecting the country's geographical diversity. Temperatures peak during the summer months (January to March) across all stations, with maximum temperatures generally between 30–35°C. For example, Katima Mulilo, located in the northeast, experiences highs around 31°C in January and February, while Keetmanshoop, in the south, can reach even higher temperatures around 34.8°C in January. Winter months (June to August) bring cooler conditions, especially in places like Windhoek, where temperatures drop to around 21°C. Rainfall in Namibia is highly seasonal and varies by region. The rainy season typically spans January to March, with areas like Katima Mulilo and Rundu receiving significant rainfall (e.g., 169.4 mm and 152.3 mm in January, respectively). By contrast, arid regions, such as Keetmanshoop, receive minimal rainfall year-round, with peaks still below 50 mm even during the wet season.

Humidity levels are relatively high in the northern regions during the rainy season, reaching around 70% in stations like Rundu and Grootfontein in March. However, drier southern areas like Keetmanshoop maintain lower humidity levels, even during peak rainfall, reflecting a semi-arid to arid climate. These climatic variations influence agricultural practices, water availability, and overall livability across Namibia, with northern regions more favorable for rain-fed agriculture, while southern and central regions face challenges due to lower rainfall and humidity.

Table 3.1: *Average climatic conditions for Namibia*

Station	Variables	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Katima Mulilo	Max T (°C)	31.3	30.5	29.8	29.1	27.4	24.5	25.0	29.1	33.8	33.0	30.3	29.8
	Min T (°C)	19.1	19.1	18.7	14.6	10.2	6.1	4.6	8.3	14.1	17.8	19.3	18.8
	Rain (mm)	169.4	160.6	88.7	17.7	1.9	0.5	0.0	0.2	2.6	18.8	69.7	151.8
	RH (%)	68	66.0	70.0	61.0	53.0	53.0	62.0	50.0	42.0	46.0	49.0	57.0
Rundu	Max T (°C)	31.1	30.9	31.4	30.7	28.9	26.5	26.1	29.5	33.1	34.6	33.9	32.6
	Min T (°C)	19.3	19.1	18.4	15.1	10.8	7.1	7.4	10.4	15.3	19.3	19.7	20.0
	Rain (mm)	152.3	138.1	84.6	28.6	2.2	0.1	0.0	0.2	3.1	21.1	53.4	80.8
	RH (%)	68	72.0	69.0	62.0	53.0	50.0	46.0	39.0	33.0	38.0	53.0	61.0
Ondangwa	Max T (°C)	31.8	30.6	30.6	30.5	28.9	26.5	26.8	29.7	33.3	34.5	33.4	32.8
	Min T (°C)	19.3	18.9	18.7	16.7	11.9	8.5	7.8	9.7	13.4	17.2	18.7	18.9
	Rain (mm)	109.3	117.5	91.5	33.9	2.9	0.6	0.1	0.0	2.1	12.7	46.6	72.2
	RH (%)	58	62.0	66.0	58.0	44.0	41.0	36.0	30.0	27.0	31.0	41.0	45.0
Grootfontein	Max T (°C)	30.9	29.8	29.4	28.5	26.5	24.0	23.8	26.8	30.6	32.1	31.9	31.3
	Min T (°C)	18.5	18.0	17.1	14.4	10.4	7.1	6.8	9.6	13.8	16.9	18.0	18.4
	Rain (mm)	141.7	127.0	99.6	30.1	4.3	0.4	0.0	1.3	4.9	21.5	51.6	70.7
	RH (%)	58	66.0	66.0	70.0	51.0	48.0	43.0	34.0	28.0	33.0	42.0	46.0
Gobabis	Max T (°C)	31.4	31.0	30.1	27.9	25.6	22.0	21.9	25.4	29.0	31.0	32.1	32.3
	Min T (°C)	18.5	17.6	15.9	12.4	7.7	3.8	3.2	5.6	10.3	14.0	16.4	18.1
	Rain (mm)	80.7	86.8	53.7	37.0	6.1	2.7	0.2	0.5	7.7	16.2	37.1	40.6
	RH (%)	45	51.0	54.0	53.0	45.0	44.0	40.0	31.0	27.0	29.0	34.0	37.0
Windhoek	Max T (°C)	30.5	29.1	27.9	26.2	23.7	21.0	21.3	23.9	27.6	29.7	30.4	31.6
	Min T (°C)	17.8	17.2	16.1	13.2	10.0	7.1	7.0	9.0	12.6	15.0	16.2	17.3
	Rain (mm)	91.3	87.0	69.5	32.3	6.2	1.2	0.4	0.8	3.8	11.4	25.7	33.2
	RH (%)	45	53.0	58.0	54.0	45.0	4.3	38.0	30.0	26.0	28.0	31.0	36.0
Keetmanshoop	Max T (°C)	34.8	34.0	32.2	28.8	25.0	21.7	21.3	23.5	27.2	30.1	32.4	34.5
	Min T (°C)	19	19.3	17.8	14.4	10.4	6.4	6.4	7.5	10.7	13.7	15.7	17.6
	Rain (mm)	24.4	42.4	36.0	14.8	5.1	1.0	1.0	0.5	3.2	5.6	10.6	13.1
	RH (%)	28	36.0	40.0	40.0	38.0	39.0	36.0	31.0	27.0	24.0	24.0	25.0
Walvisbay	Max T (°C)	20.4	19.1	20.4	19.1	19.6	18.7	18.3	16.5	15.7	16.9	17.6	19.5
	Min T (°C)	15.1	14.4	14.7	12.6	12.2	11.1	10.5	9.9	10.4	11.6	12.3	14.1
	Rain (mm)	0.9	1.4	4.4	0.4	0.9	1.0	0.0	0.2	0.1	0.2	0.4	0.1
	RH (%)	81	79.0	81.0	78.0	71.0	67.0	69.0	77.0	79.0	79.0	79.0	65.0

Source: NMS (2019)

3.2.3 Weather conditions in Omusati

Omusati lies within the Cuvelai Basin, a flat, semi-arid to arid region that experiences minimal rainfall. The Basin stretches across northern Namibia and into Angola, creating a natural, interdependent ecological system that is particularly vulnerable to droughts and floods. The region's average annual rainfall is below 250 mm, mostly occurring between November and March during short rainy seasons. These rainfall patterns are erratic, with years of severe drought alternating with occasional, intense downpours. The climate is classified as hot and semi-arid, with temperatures that often exceed 35°C during the dry season, contributing to substantial water scarcity challenges. The high evaporation rate further depletes limited water sources, impeding agricultural productivity and increasing stress on communal water resources.

Table 3.2: Omusati Weather Conditions (Monthly Averages)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Nov	Oct	Dec	Year
Record high °C (°F)	38.0 (100.4)	39.0 (102.2)	36.0 (96.8)	35.0 (95.0)	36.0 (96.8)	32.0 (89.6)	33.0 (91.4)	39.0 (102.2)	42.0 (107.6)	46.0 (114.8)	45.0 (113.0)	39.0 (102.2)	46.0 (114.8)
Average high °C (°F)	31.84 (89.31)	31.59 (88.86)	30.55 (86.99)	30.27 (86.49)	29.18 (84.52)	26.92 (80.46)	27.31 (81.16)	31.13 (88.03)	34.81 (94.66)	36.11 (97.0)	33.52 (92.34)	32.11 (89.8)	31.28 (88.3)
Daily mean °C (°F)	28.4 (83.12)	27.93 (82.27)	27.2 (80.96)	26.46 (79.63)	24.43 (75.97)	21.15 (70.07)	21.09 (69.96)	24.55 (76.19)	28.61 (83.5)	31.13 (88.03)	30.08 (86.14)	28.96 (84.13)	26.67 (80.01)
Average low °C (°F)	22.74 (72.93)	22.06 (71.71)	21.79 (71.22)	20.25 (68.45)	16.74 (62.13)	12.19 (53.94)	11.48 (52.66)	14.08 (57.34)	17.21 (62.98)	20.87 (69.57)	23.41 (74.14)	23.26 (73.87)	18.84 (65.91)
Record low °C (°F)	17.0 (62.6)	16.0 (60.8)	17.0 (62.6)	16.0 (60.8)	11.0 (51.8)	4.0 (39.2)	5.0 (41.0)	7.0 (44.6)	10.0 (50.0)	12.0 (53.6)	15.0 (59.0)	18.0 (64.4)	4.0 (39.2)
Average precipitation mm (inches)	172.08 (6.77)	156.59 (6.16)	184.55 (7.27)	43.14 (1.7)	0.74 (0.03)	0.0 (0)	0.0 (0)	0.03 (0.0)	1.5 (0.06)	20.3 (0.8)	113.47 (4.47)	186.67 (7.35)	73.26 (2.88)
Average precipitation days (≥ 1.0 mm)	16.91	14.82	19.55	6.55	0.18	0.0	0.0	0.0	0.55	4.55	13.73	17.55	7.87

The Global Historical Weather and Climate Data, (2019)

Vegetation in Omusati reflects its semi-arid conditions, consisting primarily of grassland interspersed with bush and shrub vegetation adapted to arid environments. Species such as Acacia erioloba (camel thorn), Colophospermum mopane (mopane), and various resilient grasses dominate the landscape. These vegetation types are critical to local communities as they provide fodder for livestock, materials for traditional crafts, and fuelwood for household use. However, increasing temperatures and inconsistent rainfall have led to shifts in plant species distribution, impacting livestock grazing patterns and the availability of natural resources (Mendelsohn et al., 2002). Environmental pressures have also affected Omusati's fragile soil structure. Many areas face soil erosion, exacerbated by deforestation and overgrazing, which reduces soil fertility and agricultural potential. In addition to soil degradation, the shallow groundwater sources in the Cuvelai Basin are sensitive to contamination, affecting both human and livestock health.

3.2.4 Socio-Economic Characteristics

Omusati's socio-economic landscape is shaped by its heavy dependence on subsistence agriculture, which includes both crop farming and livestock rearing. Households in the region primarily cultivate drought-resistant staple crops such as millet (mahangu), sorghum, and maize. These crops are integral to food security and are well-suited to the semi-arid environment. However, they are increasingly vulnerable to erratic rainfall patterns, making local agricultural systems highly susceptible to climate impacts (Namibia Statistics Agency, 2020). Livestock rearing, particularly of cattle, goats, and sheep, is another significant component of the region's economy. Livestock serves as a form of savings, social status, and a source of nutrition, while providing manure for crop farming. The integration of crop and livestock farming creates a traditional agro-pastoral system that is highly adaptive yet increasingly strained by environmental changes.

Despite its rich cultural heritage and traditional ecological knowledge, Omusati has limited access to modern infrastructure, healthcare, and educational resources. The region has a low Human Development Index (HDI), with high poverty rates and limited employment opportunities outside of agriculture. Public services are concentrated in towns like Outapi, Ruacana, and Okahao, leaving rural communities with minimal access to amenities. The prevalence of poverty, estimated at over 40%, restricts the capacity of households to invest in adaptive technologies or diversify their livelihoods, which exacerbates their vulnerability to climate impacts (NSA, 2023).

Access to water is a persistent challenge in Omusati. Most households rely on community wells, hand-dug wells, or seasonal water sources that fluctuate with rainfall patterns. The scarcity of reliable water sources is a significant constraint on agricultural productivity and increases the burden on women and children who typically fetch water for household use. Additionally, the region's rural electrification rate is low, with many communities relying on firewood as a primary source of energy, contributing to deforestation and environmental degradation. These socio-economic challenges highlight the precariousness of livelihoods in Omusati and underscore the need for effective community-based adaptation strategies that are affordable and sustainable in the local context.

3.2.5 Impact of Climate Variability on the Omusati Region

The impacts of climate variability are particularly pronounced in Omusati due to its reliance on rain-fed agriculture. Over recent decades, the region has witnessed an increase in the frequency and severity of extreme weather events, including prolonged droughts and sporadic flooding. Droughts have been particularly detrimental, reducing crop yields, depleting water supplies, and

forcing households to depend on government relief programs. The lack of predictable rainfall affects not only the timing of planting and harvesting but also the types of crops that can be cultivated. Crop failure rates have increased as a result, leading to food insecurity and, in some cases, forcing households to adopt coping mechanisms such as reducing meal sizes, selling livestock, or engaging in temporary migration (Department of Environmental Affairs, Tourism, and Forestry, 2019).

Floods also pose a challenge to communities in Omusati, especially in areas near the Cuvelai Basin's water channels (locally known as *oshanas*), which occasionally experience flash flooding during heavy rainfall. These floods can disrupt transportation and isolate communities, impacting access to markets, schools, and health services. Floods may also damage crops, contaminate water sources, and spread diseases, further complicating the livelihood conditions for already vulnerable communities.

3.2.6 Cultural and Traditional Knowledge Systems

Omusati's communities have a long history of resilience, relying on traditional knowledge to manage environmental stressors. Farming practices such as intercropping, crop rotation, and seed saving are common and serve to maximize yields under uncertain conditions. Traditional knowledge also influences livestock management, with herders adjusting grazing locations based on the availability of pasture and water. This indigenous knowledge system reflects a deep understanding of the environment and a cautious approach to resource management, which has been passed down through generations. However, as climate change intensifies, these traditional practices are becoming less effective, necessitating the integration of new adaptive techniques and technologies to maintain resilience (Hinz et al., 2013).

In addition to farming practices, traditional decision-making structures, such as village councils and local leaders, play a crucial role in resource allocation, land use, and conflict resolution. These structures facilitate cooperation and knowledge sharing, which are essential for adaptation strategies. Local leaders are often instrumental in mobilizing community resources during times of drought or when community-wide adaptation measures are required. Understanding and respecting these cultural frameworks is vital for any climate adaptation initiative, as they influence community acceptance and sustainability.

3.2.7 Study Significance of the Omusati Region's Characteristics

Omusati's combination of biophysical and socio-economic characteristics makes it a critical site for studying community-based climate adaptation strategies. The region's vulnerability to climate

change is amplified by its high dependency on agriculture, limited economic diversification, and insufficient infrastructure. The climate stressors, such as drought, high temperatures, and erratic rainfall, compound these vulnerabilities, creating an environment where adaptation is essential for survival. Examining adaptation practices in Omusati provides insights into how rural, resource-dependent communities respond to climate impacts, what barriers they face, and what forms of support are most effective in enhancing their resilience.

3.3 Research Design

This study employed a case study design, a methodology particularly suited for exploring complex social and environmental phenomena within their real-world context. As outlined by Yin (2018), case studies facilitate an in-depth examination of issues in specific settings, allowing researchers to gain comprehensive insights into specific communities, social dynamics, or environmental challenges. In this study, the case study design allowed for an exhaustive investigation into community-based climate adaptation strategies in the Omusati Region. It offered a rich and layered understanding of the local population's perceptions of climate change, their adaptive responses, and vulnerabilities. This study's methodology integrated both qualitative and quantitative data collection techniques, enhancing data reliability and validity through triangulation (Creswell, 2014).

The study was exploratory in nature, aiming to construct an expansive understanding of climate change impacts, food security challenges, and adaptation strategies among communal farmers in Omusati. As noted by Maree (2016), a case study focuses on a phenomenon within a defined context, preventing the scope from becoming overly broad and enabling researchers to remain focused on specific aspects of the phenomenon. Through this focused approach, this case study allowed the Omusati respondents to narrate their experiences with climate change and describe the adaptive strategies they employ. This level of participant-researcher engagement facilitated a thorough understanding of local practices, challenges, and aspirations regarding climate resilience in the community.

3.3.1 Research Approach

A mixed-methods approach, incorporating both quantitative and qualitative techniques, was used in this study to capture the diverse and multifaceted perspectives of Omusati's farmers. Quantitative methods, utilizing structured questionnaires, were key for quantifying patterns and averages, predicting trends, and testing relationships among various factors related to climate

adaptation and food security. The quantitative approach thus provided a foundation for generating broadly applicable conclusions and informing future policy recommendations.

Qualitative methods complemented the quantitative data by offering deeper insights into the lived experiences of participants. Qualitative research, as Maree (2016) defines it, involves developing a “complex, broad picture” through narrative data collection, word analysis, and comprehensive reporting of participants’ views in their natural setting (p. 309). This approach was particularly relevant to this case study, as it enabled the researcher to obtain nuanced accounts from villagers about their experiences with climate variability and adaptation strategies. Participants, including smallholder farmers and key informants, engaged through focus groups and individual interviews, were encouraged to share their stories, challenges, and successes in adapting to climate changes. These qualitative insights enriched the findings, revealing the broader socio-economic context of food security and climate adaptation among Omusati’s farmers.

By combining quantitative data on adaptive practices and qualitative narratives of adaptation, this mixed-methods approach provided a holistic view of climate adaptation in Omusati. This methodological integration not only increased the study’s depth and scope but also enhanced the robustness of findings, as the qualitative data contextualized the quantitative results, leading to a well-rounded analysis of the complex dynamics at play in communal climate adaptation.

3.3.2 Sampling Design

To obtain a representative sample for the study, a purposive sampling approach was used, with a focus on households that engaged in livestock and crop farming in Ondudu Village. This purposive sampling allowed for the collection of highly relevant information from farmers actively involved in agricultural practices, which are directly impacted by climate variability. The purposive sampling strategy, as explained by Noor (2008), is advantageous when a researcher needs to select participants with specific characteristics, thereby ensuring the relevance of the data collected to the research questions.

For quantitative data collection, a sample size of 120 households was selected, providing a fair representation of the Omusati community. A simple random sampling method was applied to this sampling frame, ensuring that each household had an equal chance of selection. This sampling frame was derived from the Namibia Statistics Agency’s (NSA) 2011 Population and Housing Census, ensuring an accurate and current basis for household selection. The 120-household sample was considered sufficient to represent the village’s population and provided a balanced cross-section of farming households across different economic and social strata.

A stratified sampling design was also applied to categorize respondents by landholding status. Households were grouped according to the size and productivity of their land, which was a key determinant of their adaptive capacity. According to Maree (2016), large sample sizes help generalize findings to a wider population; in this study, the stratified sampling design allowed for effective analysis of variations across different landholding categories, contributing to a more nuanced understanding of adaptive strategies among diverse farming households.

In addition to the quantitative sample, purposive sampling was employed for selecting key informants, such as village headpersons, Ministry of Agriculture, Water and Forestry (MAWF) officials, and Ministry of Environment and Tourism (MET) officials. These key informants were chosen based on their knowledge of local climate conditions, agricultural practices, and policy impacts on communal farming. Their insights were essential for validating information from household respondents and provided an institutional perspective on climate adaptation at the local and regional levels. The selection of these officials from government offices, NGOs, and other relevant organizations also ensured that the data collected was comprehensive and covered multiple facets of community-based climate adaptation.

3.3.3 Data Collection Strategy

Primary Data Collection

The study employed structured questionnaires for household interviews, allowing for a consistent and systematic approach to gathering quantitative data. The structured questionnaires were designed to collect specific information on climate perceptions, adaptation practices, food security issues, and socio-economic characteristics of the respondents. Heads of households were the primary respondents, but when unavailable, another responsible household member was interviewed. This flexibility ensured data collection continuity and represented the household's perspective.

Additionally, focus group discussions were conducted with village headpersons, MAWF, and MET officials. These discussions provided a platform for gathering detailed qualitative insights and served to validate household-level responses. By incorporating the perspectives of various community leaders and experts, the focus groups helped to triangulate the data and offered a broader view of communal adaptation practices and institutional support systems. The presence of an interviewer allowed participants to clarify questions and expand on responses, which not only increased response rates but also enhanced data quality.

The researcher aimed to minimize language and comprehension barriers by simplifying technical terms in the questionnaire to match the local dialect and literacy levels. This approach enabled respondents to engage fully with the questionnaire, thus increasing the data's reliability. Participants were informed of their rights and the voluntary nature of participation, ensuring ethical standards were upheld throughout the process.

Secondary Data Collection

Secondary data was gathered from various sources, including government publications, academic journals, and official reports. The Ministry of Environment and Tourism and the Ministry of Agriculture, Water and Forestry provided critical data on climate change trends, agricultural statistics, and policy interventions relevant to communal farming and food security in Namibia. Peer-reviewed journals offered additional insights on the theoretical aspects of climate adaptation and provided context for comparing Omusati's experience with broader regional and global trends.

Secondary data played a vital role in complementing primary data by offering historical context, validating household responses, and supporting the general trends observed in primary data. These secondary sources were particularly useful in understanding past climate conditions, historical adaptation practices, and policy shifts that have shaped current agricultural and adaptive practices. This combination of primary and secondary data collection methods strengthened the overall validity of the study by situating it within a broader body of knowledge on climate adaptation and food security.

3.4 Data Collection Methods

To collect a comprehensive dataset, this study employed a multi-method approach consisting of surveys, semi-structured interviews, and field observations. Each of these methods was chosen to gather specific types of information that together offered a well-rounded understanding of climate adaptation strategies in Omusati.

3.4.1 Surveys

The primary data collection method involved face-to-face surveys administered through structured questionnaires. These questionnaires were designed to capture quantitative data on household characteristics, climate change perceptions, and adaptation practices among farming households. The survey focused on closed-ended questions to facilitate statistical analysis, allowing for efficient comparisons and trend identification across responses. Closed-ended questions asked respondents to rate their experiences and practices on Likert scales, making it

possible to analyze their levels of awareness and engagement with adaptation strategies quantitatively.

Some open-ended questions were also included to capture qualitative insights that might not be fully expressed through fixed-choice options. For instance, respondents were invited to describe specific changes in rainfall patterns or share any unique adaptation practices they might have developed. These open-ended responses were later coded for qualitative analysis to support quantitative findings. The face-to-face administration of surveys also allowed the interviewer to clarify any ambiguous terms and guide respondents through the questions, increasing the accuracy and completeness of the data.

3.4.2 Interviews

Semi-structured interviews were conducted with 20 key informants, including community leaders, agricultural extension officers, and elders with extensive knowledge of traditional adaptation practices. This method was chosen because semi-structured interviews allow for a deeper exploration of topics, enabling interviewers to probe further based on respondents' answers. An interview schedule was prepared as a guide, covering core topics on climate change adaptation, community perceptions, and perceived challenges. However, the flexible nature of the schedule allowed the interviewer to delve into emerging themes and unexpected insights, providing richer data on specific adaptation strategies that were significant within the community.

Key informants were asked to elaborate on observed climatic shifts, community responses to these changes, and any long-term adaptations that might enhance resilience to future climate variability. The insights provided by these informants offered valuable perspectives on how traditional knowledge intersects with contemporary adaptation practices. This information was used to contextualize and expand upon findings from household surveys, highlighting any institutional or communal factors affecting adaptation in the region.

3.4.3 Field Observations

Field observations were conducted alongside surveys and interviews to directly document adaptation practices within their natural context. Observations were made of activities like water-saving techniques (e.g., use of water-harvesting systems), intercropping methods (e.g., growing complementary crops together to conserve moisture), and livestock management practices (e.g., rotational grazing to prevent overuse of pastureland). Observations were particularly valuable for understanding the practical aspects of adaptation, as they allowed the researcher to witness firsthand how communities implemented their strategies.

Field observations also provided an opportunity to verify and triangulate information gathered through surveys and interviews, increasing data reliability. Observational notes documented specific methods and tools used, community infrastructure, and the condition of agricultural and water resources, all of which were essential for understanding the community's adaptive practices in real-world settings.

3.5 Variables/Measures

To evaluate community-based adaptation to climate change, this study focused on several key variables: perceptions of climate change, adaptation practices, and indicators of adaptive capacity and vulnerability. These variables were carefully measured to capture a comprehensive picture of local adaptation efforts and challenges.

3.5.1 Perceptions of Climate Change

The study examined community perceptions of climate change through indicators such as perceived changes in temperature, rainfall patterns, and frequency of extreme weather events. These indicators were measured using a Likert scale, where participants rated their observations of climate shifts over recent years. This scale allowed for a nuanced view of climate perceptions, enabling analysis of community awareness and levels of concern about climate variability. Data on climate perceptions were essential for assessing the extent to which communities recognize environmental changes, which can influence their adaptive behavior and willingness to engage in resilience-building practices.

3.5.2 Adaptation Practices

Adaptation practices were another focal variable, capturing community strategies for coping with climate impacts. The study examined a range of practices including crop diversification, soil conservation, water-saving methods, livestock management, and migration. Each of these practices was coded quantitatively to allow for comparative analysis across households. For instance, responses related to crop diversification (e.g., shifting to drought-resistant crops) and soil conservation methods (e.g., mulching, use of compost) were categorized and assessed for prevalence and effectiveness.

This coding of adaptation practices allowed for quantification and comparison, identifying the most common strategies within the community and how they varied among different respondent groups. By analyzing the data, the study identified potential gaps in adaptation practices and areas where further support or resources might enhance resilience.

3.5.3 Adaptive Capacity and Vulnerability

Adaptive capacity and vulnerability were measured through indicators encompassing access to resources, social support, governance structures, and dependency on natural resources. To assess adaptive capacity, factors like financial resources, access to agricultural training, and community knowledge of climate risks were rated on a Likert scale. Higher ratings indicated greater adaptive capacity, highlighting households that might be more resilient to climate impacts due to resource access or experience.

Vulnerability was assessed based on factors such as reliance on rain-fed agriculture, poverty levels, and the strength of social support systems. These indicators provided insights into the community's exposure to climate risks, with households dependent on rain-fed agriculture or with limited social networks deemed more vulnerable. By identifying adaptive capacity enablers and barriers, the study could better understand the community's resilience and areas for potential intervention. This analysis highlighted socio-economic disparities within Omusati and pointed to specific needs for resource provision, training, and support.

3.6 Data Analysis

The data analysis for this study employed both quantitative and qualitative techniques to provide a comprehensive understanding of the community-based adaptation strategies in the Omusati Region. These methods allowed for triangulation of the data, enhancing the validity and reliability of the findings, and ensuring that insights aligned with the study's objectives of assessing climate perceptions, adaptation practices, and the socio-economic factors affecting adaptive capacity.

3.6.1 Quantitative Data Analysis

Quantitative data, gathered primarily through surveys, were analyzed using descriptive and inferential statistical techniques. Descriptive statistics were used to summarize the demographic characteristics of respondents, their perceptions of climate change, and the range of adaptation practices employed. Measures such as frequencies, means, and standard deviations were calculated to provide an overview of key variables like age, gender, household size, and agricultural practices. This provided a foundational understanding of the profile of the farming communities within Omusati and their general stance on climate change impacts and adaptive actions.

Data analysis was performed using the *Statistical Package for the Social Sciences (SPSS), version 27* (IBM Corp., 2020). Thus, inferential statistical analysis was applied to explore relationships between adaptive capacity and various socio-economic factors, such as access to

resources, social support, and education level. Correlation analyses were employed to investigate the strength and direction of relationships between continuous variables, such as household income and access to adaptive resources (Field, 2018). According to Amemiya (1985), logistic regression is a model used for predicting the probability of an event occurring by fitting data to a logistic curve. In this case the model was used to measure factors that influence the adoption of strategies used to build resilience and adaptation to climate change. The general model is given by:

$$Y = b0 + bX1 + bX2 + \ldots\ldots\ldots + bXn$$

Y = either 0 or 1, where 0 means no use of the strategy and 1 means use of the strategy.

Y is the adaptation/ resilient strategy as presented by the results from the survey. Xn represents variables that influence the implementation of resilience and adaptation strategies, and these can be divided into the following categories: demographic factors, access to information and technologies, assets and resources, farmer training and access to informal institutions, determined by the survey results

These inferential tests allowed for deeper insights into which factors might serve as enablers or barriers to effective adaptation, supporting the objective of identifying socio-economic conditions that affect adaptive capacity. Results from the quantitative analysis provided key statistical evidence that informs the recommendations in later chapters, specifically in guiding resource allocation and policy support to enhance resilience.

3.6.2 Qualitative Data Analysis

Qualitative data, gathered through semi-structured interviews and field observations, were analyzed thematically. NVivo software was employed to facilitate the coding and organization of qualitative data, enabling efficient identification of themes and patterns related to the community's adaptation practices, perceptions of climate variability, and challenges encountered in implementing adaptive strategies. The thematic approach allowed for an in-depth exploration of socio-cultural factors that underpin the community's adaptation responses.

Thematic analysis began with initial coding, where phrases or statements related to specific aspects of adaptation were assigned labels. For example, interview responses concerning water conservation practices were coded under themes like "resource scarcity" and "traditional knowledge." Once codes were established, they were grouped into broader themes aligned with the study's objectives, including "adaptation strategies," "climate perceptions," and "barriers to

adaptation." This process enabled a nuanced examination of the social and cultural dynamics influencing adaptation decisions, offering context to quantitative findings.

Field observations contributed additional depth to the thematic analysis by providing visual and contextual evidence of adaptation practices. Observations of specific practices, such as intercropping and water-harvesting techniques, were recorded and aligned with themes identified in interviews. This triangulation between data sources strengthened the reliability of qualitative insights and allowed for a more holistic view of how local communities are responding to climate pressures.

3.6.3 Presentation of Findings

The findings from both quantitative and qualitative analyses are presented in Chapter 4, organized by the study's objectives. Quantitative results are displayed through tables and charts to illustrate demographic data, frequency of adaptation practices, and relationships between variables, supporting objective evaluation of the data. Qualitative findings are presented thematically, with illustrative quotes from key informants and household members, capturing the community's voices and providing context to the quantitative data.

Overall, the combined data analysis methods allowed this study to fulfill its objectives by quantifying the relationships between socio-economic factors and adaptive capacity while exploring the lived experiences and contextual realities of climate adaptation at the community level. The integration of quantitative and qualitative findings contributes to a comprehensive understanding of adaptation challenges and enablers, providing evidence-based recommendations to improve resilience and adaptive capacity among communal farmers in the Omusati Region.

3.7 Ethical Considerations

Ethical considerations were foundational to this study, ensuring that the rights, welfare, and dignity of participants were respected throughout the research process. According to Nciizah (2019), obtaining ethical approval is essential for protecting participant rights, minimizing risks, and upholding the integrity of the research institution, in this case, the University of the Free State. This study received ethical clearance from the University of the Free State's Ethics Committee, a necessary endorsement to safeguard participant well-being and the researcher's accountability. Additionally, permissions were sought and obtained from the Omusati Regional Council and the local authorities in Ondudu Village, specifically village heads and community leaders, which was instrumental in fostering trust and cooperation with the local community.

Obtaining informed consent was a critical component of ethical compliance. Before engaging participants in surveys, interviews, or observations, the researcher provided them with a clear and accessible explanation of the study's objectives, methods, and anticipated outcomes. Nciizah (2019) emphasizes the importance of transparency, noting that participants must be fully informed about the research's purpose, procedures, and any potential risks or benefits involved. The information was communicated in straightforward language to ensure that participants of varying educational backgrounds could fully understand what was expected of them.

Voluntary participation was emphasized, and participants were informed of their right to withdraw from the study at any point without repercussions. Consent forms were provided in both written and verbal formats, where necessary, to accommodate literacy levels and participant comfort. Respondents were given sufficient time to ask questions and consider their involvement, reinforcing a respectful and non-coercive approach to data collection.

Confidentiality and anonymity were key ethical principles observed in this research. Personal data, including names, contact information, and any identifiers, were kept confidential to protect the privacy of respondents. The data collected was anonymized, with personal identifiers removed or replaced with pseudonyms, ensuring that participants could not be identified in the study's findings. Secure storage protocols were maintained, with electronic data protected by passwords and physical data stored in a secure location, accessible only to the researcher and authorized personnel.

In presenting the findings, the study was careful to avoid attributing specific statements or experiences to identify individuals. This approach mitigated any potential harm or discomfort that might arise from sharing sensitive information, particularly given the local context, where climate adaptation and agricultural practices are closely linked to individual livelihoods and community status. While this research did not involve any physical interventions, the potential for emotional discomfort was carefully considered, especially given that climate adaptation and food security are sensitive issues that may evoke concerns among participants. The researcher remained attentive to signs of discomfort during interviews and was prepared to cease discussions if participants exhibited distress or reluctance. Participants were reassured that their responses would be respected and that they were under no obligation to answer questions they found uncomfortable.

Additionally, community leaders were consulted to identify any cultural norms or sensitivities that should be observed during interactions with participants. This local engagement strategy not only helped tailor the study to the community's context but also served to protect participants from any

unintended harm. This study aligns with the University of the Free State's guidelines on research ethics, underscoring the responsibility of researchers to protect both participants and the reputation of the academic institution. By following these ethical guidelines, the researcher maintained a professional and respectful approach, building trust with participants and the local community. Furthermore, regular reporting and updates to the University's Ethics Committee were maintained, ensuring compliance with ethical standards at all stages of the research.

3.8 Chapter Summary

This chapter has detailed the methodological approach employed in this study, including the study area description, research design, sampling methods, data collection tools, variables, data analysis techniques, and ethical considerations. The methods outlined here provide a robust framework for examining community-based climate adaptation strategies in the Omusati Region. In the following chapter, Chapter 4, the study's findings are presented, analyzing the data in relation to the research questions and objectives.

Chapter 4: Results and Discussion

4.1 Introduction

This chapter presents the findings from a detailed climate change adaptation study conducted in Omusati, Namibia, with a focus on the community's perceptions, experiences, and responses to climate change impacts. Through a comprehensive analysis, this chapter reveals the intricate relationships between demographic factors such as age, gender, education level, and income, and the adaptation strategies employed by community members to enhance their resilience. Key adaptation strategies identified include diversification of livelihoods, sustainable agricultural practices, water conservation efforts, and livestock management. Each of these strategies is discussed in relation to how they strengthen or, in some cases, hinder the community's ability to withstand climate-related challenges.

The chapter also highlights the need for targeted interventions to support these adaptation efforts and build community resilience more effectively. The analysis suggests that certain demographic groups, such as low-income households and those with limited education, face additional challenges in accessing resources or implementing effective strategies. Therefore, policies should prioritize these vulnerable groups to ensure equitable adaptation support across the community.

In addition to presenting the findings, this chapter provides into the implications of the study for policy and practice. It underscores the importance of addressing identified gaps, such as limited access to markets, inadequate infrastructure, and a lack of technical knowledge. The discussion also acknowledges limitations of the study, such as sample size constraints and limited longitudinal data, and offers recommendations for future research. By examining the complex dynamics of climate change adaptation in Omusati, this study provides valuable insights for developing evidence-based strategies to support vulnerable communities, ultimately informing climate adaptation policy and practical interventions.

4.2 Community Knowledge and Perceptions of Climate Change

4.2.1 Omusati demographic information

The age-gender distribution in Table 4.1 provides insights into the population structure of the Omusati community, particularly focusing on gender proportions across different age groups. For the 20-25 age group, males make up a significant majority at 67%, compared to only 33% females, which indicates a potential male dominance in the younger population segments. This trend

continues, though slightly decreasing in male dominance, across the age groups up to 40 years old, where males consistently form the majority, representing between 60% and 67% of each age category. However, in the 40+ age group, this trend reverses, with females making up 60% and males only 40%. This shift might reflect social or cultural dynamics, such as men migrating out of rural areas or lower life expectancy among men.

Table 4.1: Age-Gender Distribution in Omusati

Age Group	Male	Female	Total
20-25	67%	33%	8%
26-30	62%	38%	56%
31-35	60%	40%	13%
36-40	59%	41%	13%
40+	42%	58%	13%
Unknown	-	-	3%
Total	58%	30%	88%
Missing	-	-	12%

The table also reveals that there is a small percentage (3%) of respondents with unknown age, all of whom are female. Additionally, there's a 12% missing data rate in the total population, which could affect the overall representativeness of the data. Overall, the gender distribution data provide valuable insights into the age dynamics of males and females, which could influence community structure, labor distribution, and adaptation strategies to climate change.

This gender-age distribution aligns with one of the research objectives, which aims to understand demographic influences on climate adaptation strategies. The male dominance in younger age groups could suggest that adaptation practices or resilience measures might be shaped by male perspectives, potentially leading to gender-specific adaptation challenges. Conversely, the higher female proportion in the older demographic could highlight women's critical roles in maintaining household resilience, especially among older populations.

This pattern of male dominance in younger age groups is consistent with migration studies in rural African communities, where men often move to urban areas or other regions for work, resulting in female-majority older populations. This demographic insight will be essential when considering literature that emphasizes the role of gender in resilience strategies, where female-led households may have unique adaptation needs due to resource limitations and social roles.

Table 4.2: Age-Education Level Distribution

Age Group	Matriculant	Graduate	Post-Grad	Other
20-25	33%	33%	33%	0%
26-30	14%	33%	48%	5%
31-35	20%	40%	40%	0%
36-40	10%	20%	60%	10%
40+	10%	0%	20%	70%
Unknown	0%	0%	0%	100%

Table 4.2 provides the distribution of educational attainment across different age groups. In the youngest age group (20-25 years), there's a balanced representation across matriculants, graduates, and post-graduates, each comprising 33%. However, as the age groups progress, the level of education among individuals tends to increase. For instance, in the 26-30 age group, post-graduate qualifications reach 48%, indicating a tendency toward higher education levels as people grow older, possibly due to cumulative educational attainment over time.

In the 36-40 age group, the majority (60%) have post-graduate qualifications, with only 10% reaching matriculant level. Interestingly, in the 40+ age group, a substantial portion (70%) falls under the "Other" category, potentially indicating limited formal education or non-traditional forms of education, which could reflect older community members' limited access to educational resources in the past. Additionally, respondents with unknown age group fall entirely under "Other," further emphasizing the need for targeted educational initiatives.

Educational attainment can play a critical role in climate adaptation, as more educated individuals might have better access to climate information, new technologies, and diversified livelihood strategies. This table supports the research hypothesis that education levels correlate with adaptive capacity, with higher education potentially enhancing resilience by providing individuals with knowledge and skills for sustainable adaptation practices.

These results are consistent with adaptation literature that highlights education as a crucial factor in resilience. Educated individuals tend to adopt innovative practices and sustainable approaches, especially in communities vulnerable to climate change impacts. This educational distribution also reflects patterns observed in other rural communities, where younger generations have improved educational access compared to older generations.

These findings address a key research gap identified in the literature review regarding the relationship between demographic factors and climate adaptation strategies in rural Namibian communities. By identifying the demographic patterns of gender, age, and education, this study offers evidence-based insights that could guide policymakers in designing targeted climate adaptation programs that address the unique needs of each demographic group.

4.2.2 Farming Practices in Omusati

The data on crop production practices in Omusati indicate that the majority of farmers engage in diversified farming systems. Only 8 respondents focus exclusively on crop production, which suggests that sole reliance on crops may be less common in this region, likely due to climatic risks such as droughts or inconsistent rainfall that make diversified farming more resilient. A larger proportion (18 respondents) practice a combination of crop and livestock farming, while 36 respondents engage in mixed farming with crops, livestock, and poultry, showing a preference for multiple income streams. Mixed farming, which combines crop, livestock, and poultry production, is the most common approach, potentially because it enhances food security and economic resilience by spreading risk across different agricultural products. This variety of farming practices aligns with adaptation strategies aimed at managing climate risks, as households can depend on alternative resources if one type of production is affected by adverse climate conditions.

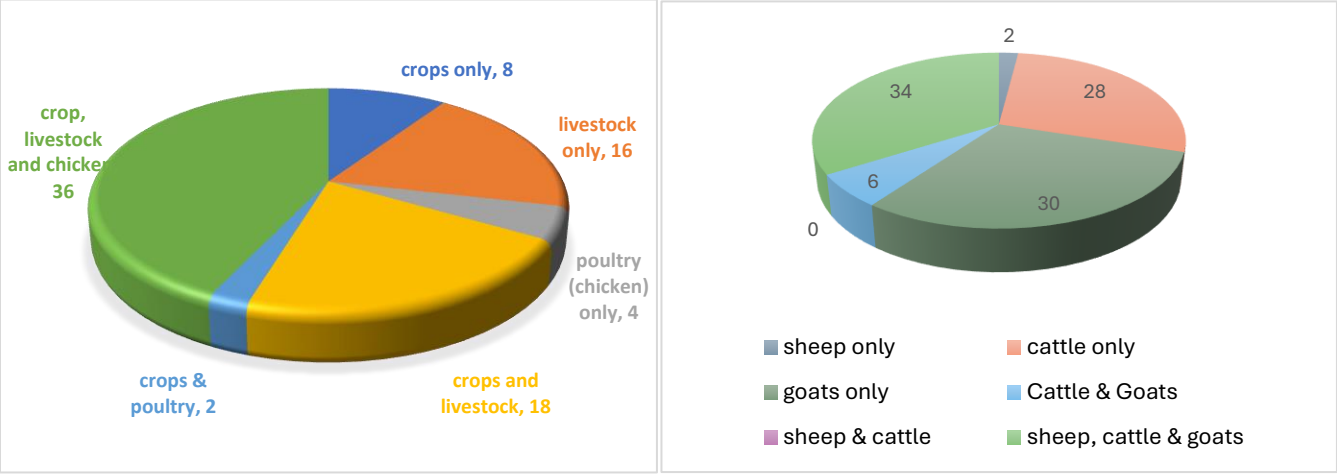


Figure 4.1: Farming Practices in Omusati

Regarding livestock production, the data show that 30 respondents raise goats exclusively, while 28 focus on cattle only. Goats are often favored in arid regions due to their hardiness and ability to thrive on minimal resources, which makes them suitable for Namibia's dry climate. A small number of respondents (2) keep only sheep, while 34 respondents raise a combination of sheep,

cattle, and goats. This mixed livestock approach is beneficial, as it diversifies income and offers flexibility, with goats and sheep being well-suited to the harsh, drought-prone environment and cattle providing both financial and nutritional benefits when conditions allow.

The mixed livestock practice (sheep, cattle, and goats) indicates an awareness among farmers of the benefits of diversification in enhancing resilience to environmental challenges. Having different types of livestock can reduce the risk of losing all animals during a drought or disease outbreak, as different species may have varying levels of resistance or adaptation to specific stresses.

These findings directly relate to the research objectives, which aim to understand how community-based farming practices contribute to resilience against climate change. The dominance of mixed farming approaches suggests that farmers in Omusati are adopting adaptive strategies to safeguard their livelihoods against climate variability. By combining crops, livestock, and poultry, households can leverage multiple sources of food and income, reducing vulnerability to seasonal shifts and adverse weather.

This analysis helps address a key research gap identified in the introduction and literature review chapters, which is the lack of detailed understanding of local adaptive farming practices in response to climate impacts. The preference for mixed farming observed in Omusati suggests that farmers are intuitively adopting diversification as a resilience strategy, supporting theories on agricultural resilience that emphasize diversification as a means to mitigate climate risk. The findings align with adaptation theories that emphasize diversification as a central pillar of resilience. Theoretical frameworks on climate adaptation, such as the Sustainable Livelihoods Framework, support the idea that livelihood diversification is crucial for managing climate risk in rural communities. Studies in other semi-arid regions, such as those by Ellis (2000) and Thornton et al. (2014), indicate similar trends where households integrate various types of farming to stabilize income and food production. The patterns in Omusati mirror these broader findings and reinforce the significance of mixed farming as a local strategy to enhance resilience in a climate-vulnerable setting.

4.2.3 Climate change perception

Figure 4.2 reveal a 100% awareness of climate change across all age groups and education levels, indicating that climate change awareness is pervasive among respondents in Omusati. However, the distribution across education levels suggests that higher education may influence a

more nuanced understanding, as seen in the concentration of post-graduate respondents (51%) who are aware of climate change. This pattern could indicate that individuals with higher education levels might better understand complex environmental issues. For younger age groups, awareness is also high (100% in the 20-25 age group), possibly due to exposure to climate education or media. This finding aligns with studies indicating that education enhances awareness of climate change, as educated individuals are more likely to engage with environmental issues (UNESCO, 2020).

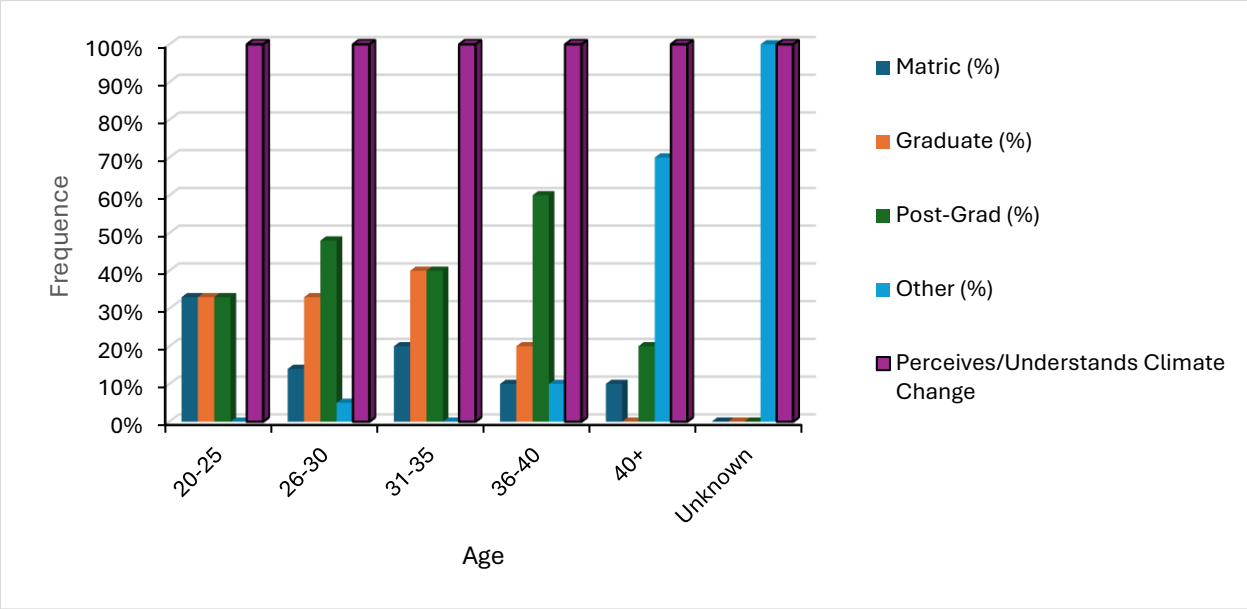


Figure 4.2: Climate change understanding by age and education level.

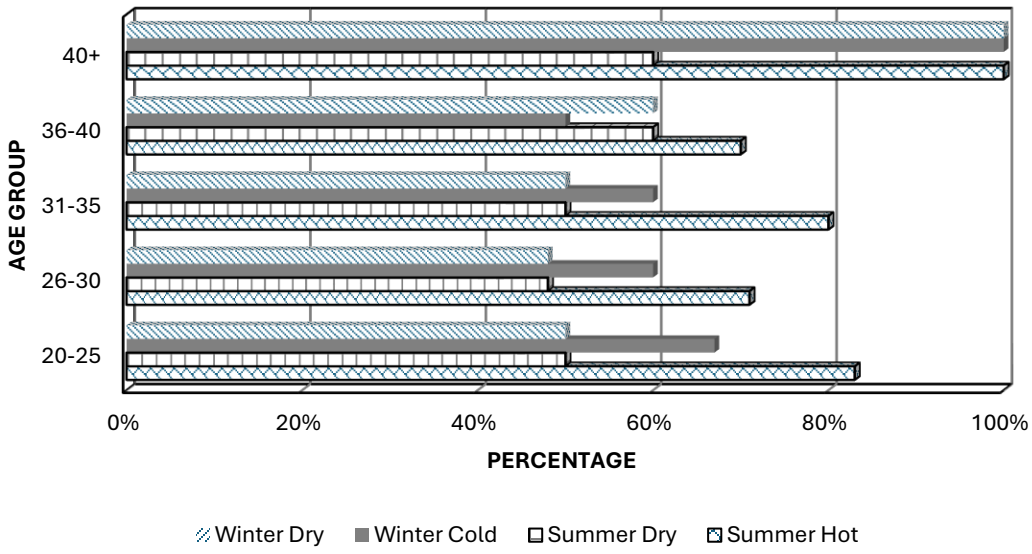


Figure 4.3: Seasonal Climate Understanding by Age Group

Figure 4.3 shows perceptions of seasonal climate characteristics across different age groups. Summer is generally perceived as hot by a high proportion of respondents in all age groups, with 100% in the 40+ category recognizing this characteristic. However, perceptions of dryness in summer and winter vary, with the older age group (40+) showing a higher agreement (60%) on summer dryness. Winter is perceived as cold by 100% of respondents in the 40+ age group, indicating a possible generational perspective on traditional seasonal weather patterns. Younger age groups, however, report slightly lower recognition of "cold" winters, suggesting they may perceive seasonal changes differently. This intergenerational difference in seasonal perception could be due to lived experience, where older individuals have experienced more climate variability over time.

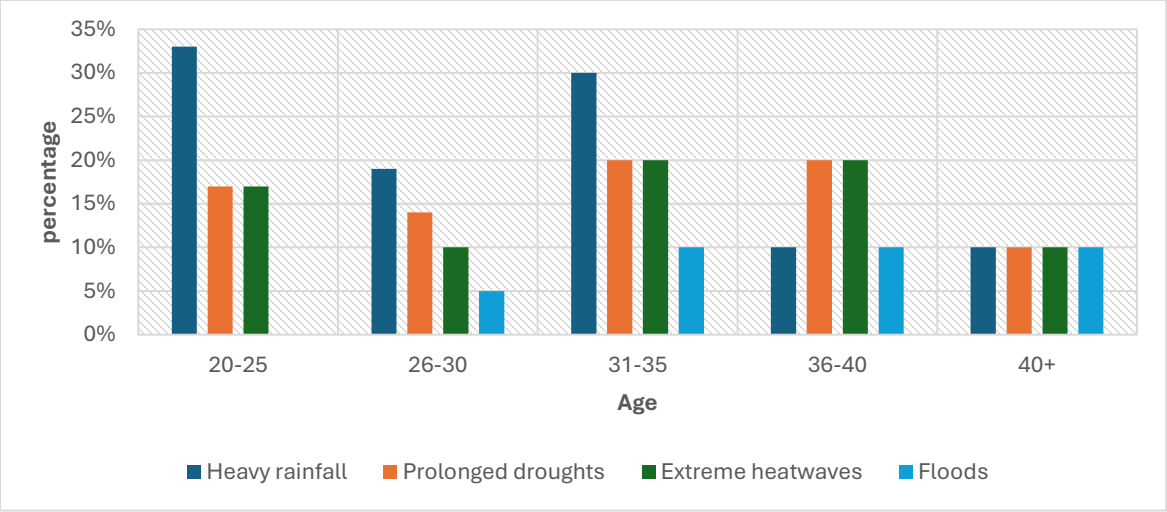


Figure 4.4: Observed unusual weather phenomena by age group

Figure 4.4 highlights the types of unusual weather phenomena observed across age groups. Heavy rainfall is the most commonly observed phenomenon, particularly by younger respondents (33% in the 20-25 group), while older age groups report fewer observations. This pattern may suggest that younger people are more aware of recent weather changes or more likely to interpret heavy rainfall as unusual. Older respondents report prolonged droughts and extreme heatwaves more frequently, possibly reflecting long-term exposure to these phenomena and a historical context for evaluating climate patterns. This difference in observations across age groups indicates a variety of experiences with climate change impacts, potentially shaping adaptation strategies.

Table 4.3: Observed shifts in Seasonal Patterns by Education Level

Seasonal Shift	Matric	Graduate	Post-Grad	Other
Earlier summer	42%	36%	18%	25%
Later winter	25%	27%	15%	25%
Changes in rainfall timing	17%	18%	9%	25%
Increased temperature variability	8%	9%	6%	0%

Table 4.3 shows that perceptions of seasonal shifts vary by education level. Matriculants report higher rates of noticing an earlier summer (42%), which may suggest they are more attuned to immediate seasonal changes, perhaps due to direct agricultural dependence. Graduates and post-graduates report observing changes in rainfall timing and temperature variability, albeit at lower rates. These results imply that education may broaden awareness of complex climate dynamics beyond seasonal timing, enhancing sensitivity to less obvious shifts like temperature variability. Individuals with higher education levels may also understand these changes within a broader scientific framework, as they are more likely to have exposure to climate information and environmental science.

These findings contribute to understanding the community's perceptions of climate change, addressing the research objective of assessing climate awareness and knowledge across demographics. The varied perception of seasonal patterns and unusual weather by age and education supports the hypothesis that demographic factors influence climate change awareness and adaptive capacity. Individuals with higher education levels might perceive climate change impacts differently due to increased exposure to scientific information, while age affects awareness through lived experiences.

The results address the research gap related to the influence of demographics on climate change perception and adaptation in communal farming areas. The detailed demographic analysis shows that while awareness is high, the interpretation of specific climate phenomena varies, suggesting the need for tailored climate education that considers both age and education level. This approach could bridge knowledge gaps, empowering younger and less educated individuals to engage in informed adaptation strategies.

These findings align with the Environmental Belief Model, which suggests that environmental perceptions are influenced by education and personal experiences. Studies in rural African communities show similar patterns, where education increases awareness of climate change but may not always lead to deeper engagement without experiential knowledge (Ndhlovu, 2019). The

results also resonate with theories of adaptive capacity that emphasize the role of knowledge in shaping climate resilience. This analysis provides a nuanced perspective on how different segments of Omusati's population perceive climate change, which is essential for designing inclusive and effective climate adaptation interventions

4.3 Climate Adaptation and Resilience

Table 4.4 provides an overview of the adaptation strategies employed by farmers in the Omusati region, categorized into Agricultural Practices, Water Management, Livestock Management, Diversification Strategies, and Other. The percentage of farmers using each category shows that Agricultural Practices are the most popular (56%), followed by Water Management (35%) and Livestock Management (28%). Diversification Strategies are less common (21%), though they have the highest mean effectiveness score (3.9) with a relatively low standard deviation (0.8), indicating consistent effectiveness across users. Agricultural Practices also score highly (mean of 3.8), showing their reliability among farmers. This suggests that farmers in Omusati prioritize strategies they consider effective and accessible, such as crop rotation and drought-resistant crops, to mitigate the effects of climate change on agriculture.

Table 4.4: Adaptation Strategies employed by farmers in Omusati

Category	Percentage	Effectiveness	
		Mean Score	Std. Dev.
Agricultural Practices	56%	3.8	0.9
Water Management	35%	3.5	1.1
Livestock Management	28%	3.2	1.2
Diversification Strategies	21%	3.9	0.8
Other	14%	3.6	1.0

The lower percentages for Livestock Management and Diversification may be due to resource constraints or lack of awareness of these strategies' potential benefits. Livestock Management's lower mean score (3.2) and higher standard deviation (1.2) imply that it is less effective or varies in effectiveness, likely because livestock are vulnerable to drought and heat stress. These findings align with studies that highlight the need for more diversified adaptation approaches to improve resilience in rural communities (Adger et al., 2005).

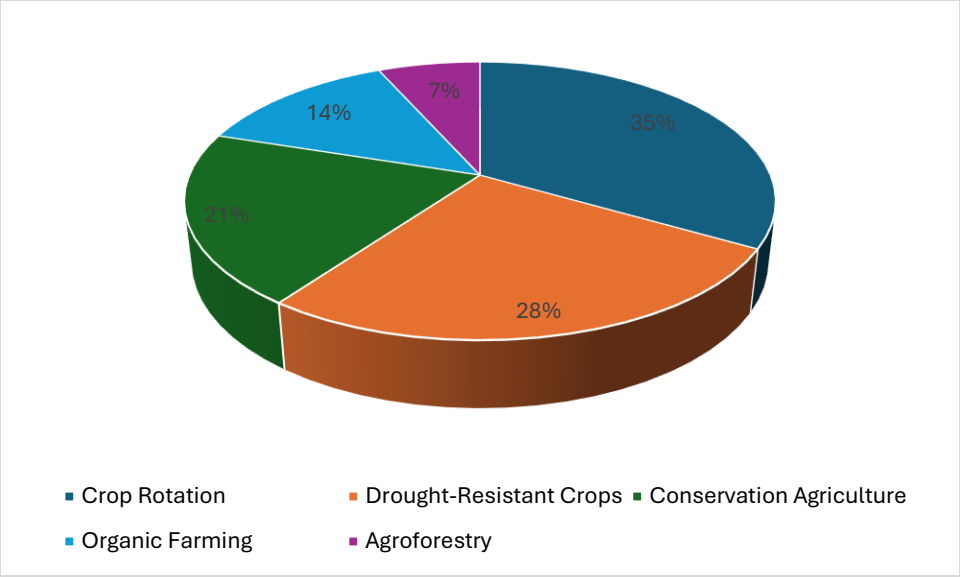


Figure 4.5: Sustainable crop farming strategies

Figure 4.5 above highlights the sustainable crop farming strategies employed by farmers in Omusati. Crop rotation is the most widely adopted practice (35%), followed by drought-resistant crops (28%) and conservation agriculture (21%). Organic farming (14%) and agroforestry (7%) are less common. The high adoption of crop rotation and drought-resistant crops suggests that farmers recognize the importance of maintaining soil fertility and enhancing crop resilience to changing climate conditions. Conservation agriculture is moderately used, reflecting a growing awareness of soil health practices. However, agroforestry's low adoption rate may indicate that it is either resource-intensive or that farmers have limited knowledge or access to suitable tree species. These results indicate that while farmers are adopting some sustainable practices, additional support or education on less commonly used methods could enhance resilience.

Figure 4.6 below shows that livestock management strategies in the Omusati region focus on supplementary feeding (21%), stocking control (14%), and drought-tolerant breeds (7%). Supplementary feeding is likely a response to the decreasing availability of natural pasture during droughts. Stocking control helps manage livestock population sizes to reduce pressure on limited resources, and drought-tolerant breeds offer resilience against high temperatures and water scarcity. However, the low adoption of drought-tolerant breeds indicates a possible lack of access to suitable animals or knowledge of their benefits. This aligns with literature suggesting that access to resources and extension services is crucial in promoting adaptive livestock management practices (Lal et al., 2011).

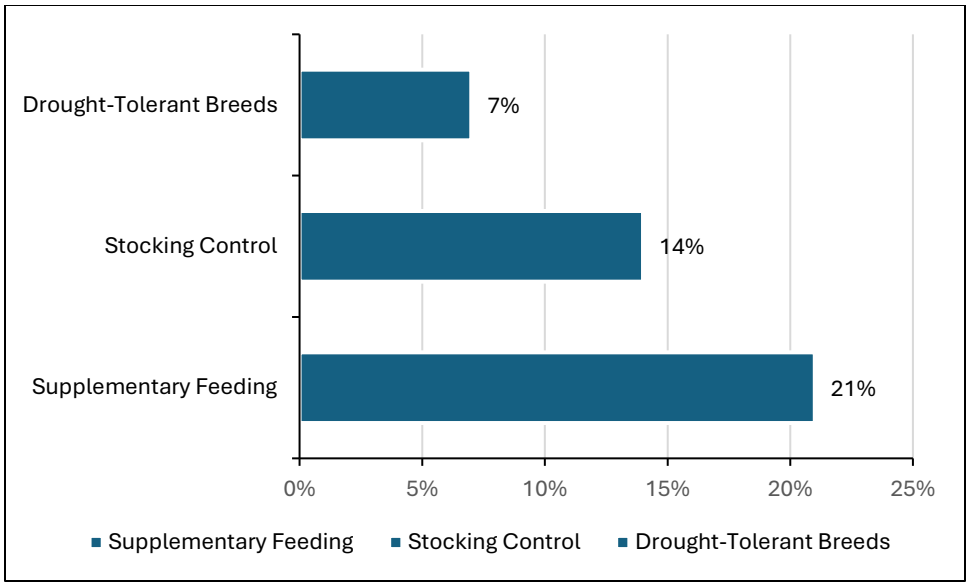


Figure 4.6: Livestock Management Strategies

In Figure 4.7 below, which show specific water management practices, rainwater harvesting (20) and drilling boreholes (15) are the most common practices, followed by irrigation (10) and water conservation (5). Rainwater harvesting is an accessible method for smallholder farmers to store water during the rainy season, while boreholes provide a more reliable water source, especially in drought-prone areas. However, the limited use of irrigation and water conservation practices could indicate a lack of infrastructure or technical knowledge among farmers. This aligns with studies emphasizing the need for investment in water management infrastructure to support climate resilience (Nhamo et al., 2019).

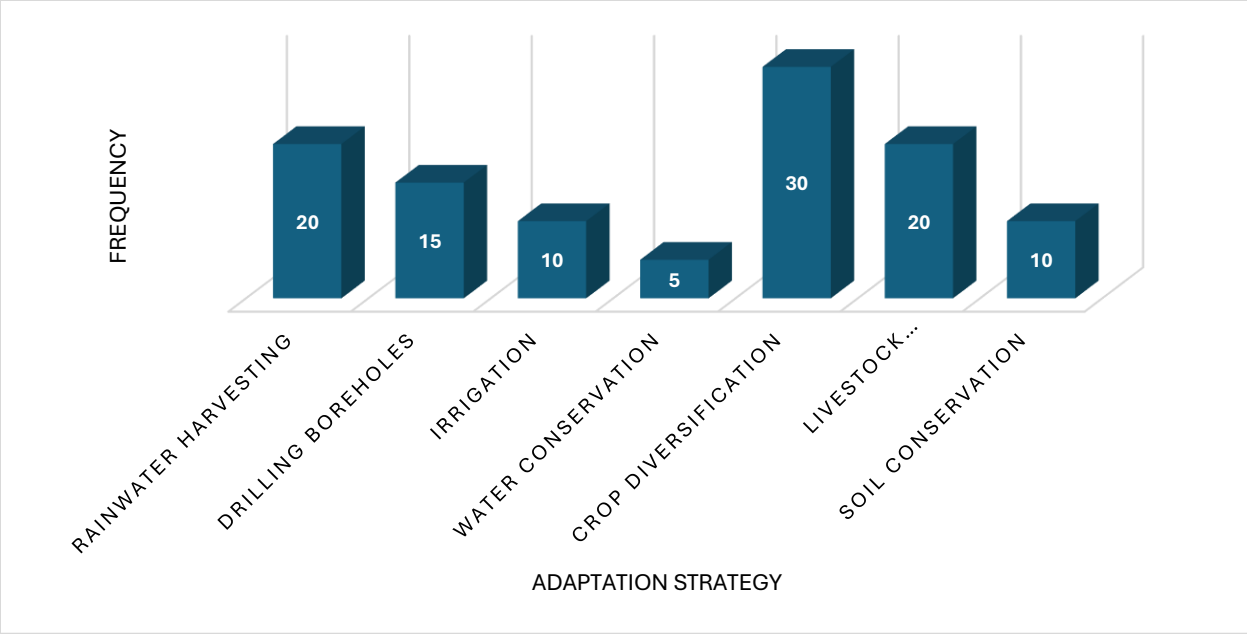


Figure 4.7: Specific Adaptation Strategies employed by farmers.

Crop and livestock diversification are also highlighted in Figure 4.7, with crop diversification (30) being more widely used than livestock diversification (20). Crop diversification helps reduce the risk associated with reliance on a single crop, improving resilience to market or climate shocks. The adoption of livestock diversification indicates that farmers are trying to balance risks by keeping different animal species, which may have varying resilience to drought. However, low overall diversification adoption (21%) suggests that farmers may face challenges such as limited land, financial resources, or knowledge, which restrict their ability to diversify.

The adaptation strategies observed contribute to understanding how farmers in Omusati respond to climate variability and align with the research objective of assessing local adaptation methods. The high adoption of certain strategies like crop rotation and rainwater harvesting shows farmers' resilience and adaptive capacity. However, limited use of more advanced strategies (e.g., drought-tolerant breeds, agroforestry, water conservation) suggests that knowledge or resource gaps may inhibit widespread adoption, which was highlighted as a gap in literature.

These findings address the research gap related to the specific adaptation strategies used by communal farmers and their effectiveness. The study reveals that while farmers employ a variety of strategies, there is potential to improve the effectiveness and adoption of certain practices, especially in water and livestock management. By understanding which strategies are more effective and accessible, targeted interventions can be designed to enhance resilience.

The findings align with the Sustainable Livelihoods Framework, which emphasizes the role of diversified assets and practices in building resilience (Scoones, 1998). The reliance on agricultural and water management practices, as well as crop diversification, supports this framework, as these practices enable farmers to cope with and adapt to environmental stressors. The study also echoes the Adaptive Capacity Theory, which posits that knowledge, access to resources, and institutional support are essential for effective adaptation (Smit & Wandel, 2006). By highlighting the gaps in adoption of certain strategies, this study emphasizes the need for capacity-building efforts, such as training and resource provision, to empower farmers in adopting comprehensive adaptation practices.

In summary, while Omusati farmers employ various strategies to adapt to climate impacts, further support is necessary to enhance resilience, especially in underutilized practices. This understanding contributes to the broader knowledge of communal adaptation practices in Namibia, providing insights for policy interventions that address the specific needs and challenges of rural communities facing climate change.

4.4 Community Vulnerability Assessment

4.4.1 Vulnerability Indicators

This section (Figure 4.8) identifies the main vulnerability indicators within the community. Food Security ranks as the highest indicator of vulnerability at 71%, followed by Access to Water (57%), Livestock Management (43%), Health (36%), and Education (29%). The prioritization of food security aligns with the community's reliance on agriculture, where crop yields are directly impacted by climate variability, such as drought and irregular rainfall, which affects both food supply and livestock management. Access to water being the second-highest concern is consistent with literature on the arid regions in Namibia, where water scarcity significantly impacts agricultural productivity (Niang et al., 2014). Health and education show lower percentages, which may indicate that while they are crucial for overall resilience, they are less immediately impacted by climate than food and water accessibility.

This breakdown of vulnerability indicators supports one of the key research objectives: assessing primary vulnerabilities and understanding how these affects adaptive capacity. The findings align with the Sustainable Livelihoods Framework, which underscores the importance of addressing key vulnerabilities, such as access to essential resources, to build community resilience.

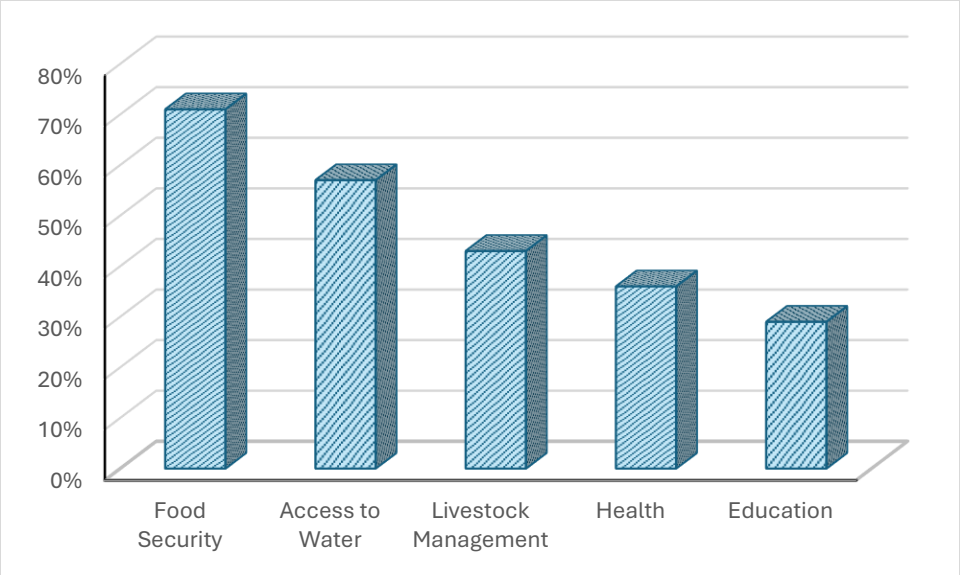


Figure 4.8: Vulnerability Indicators Identification

Figure 4.9 categorizes the community into three vulnerability levels: High, Medium and Low. The criteria for high vulnerability—limited water access, food insecurity, and poor health—reflects the struggle of these households to secure basic resources, likely due to either location or socioeconomic factors limiting their access to adaptive resources. The medium vulnerability group has moderate access to these essentials, with some level of food security and adequate health services, indicating that they are less impacted but still at risk. The low vulnerability group enjoys reliable access to water and food security and experiences good health, suggesting that they may have more adaptive capacity, possibly through diversified income or resources that help them withstand climate impacts.

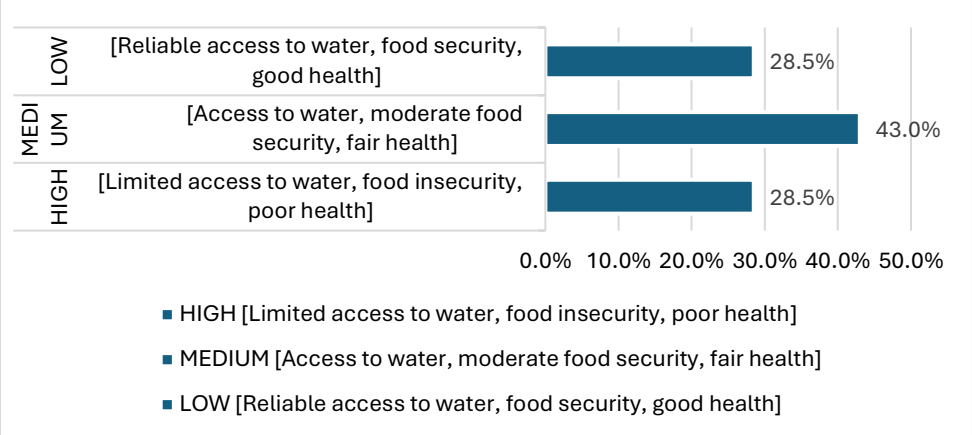


Figure 4.9: Categorization of Vulnerability Levels

The relatively high percentage of households in the medium vulnerability category shows that the community has varied access to adaptive resources. This distribution suggests that while some households are highly vulnerable, others have managed to improve their resilience, possibly by adopting adaptation strategies that increase food and water security. This aligns with theories of adaptive capacity, which highlight how social and economic factors influence resilience (Smit & Wandel, 2006).

4.4.2 Understanding Factors Affecting Adaptation.

The Correlation Matrix analysis presented in the table below examines the complex interplay between different demographic variables and the implementation of specific resilience and adaptation strategies to climate change by smallholder farmers (Table 4.5). The results uncover subtle trends that enhance our holistic understanding of the elements driving adaptive actions in this agricultural setting

Table 4.5: Factors influencing adaptation and resilience strategies to climate change

	Age	Gender	Education Level	Income Level	Household Size	Household Composition	Farm Size	Diversification of Livelihoods	Sustainable Agricultural Practices	Water Conservation	Use of Drought-Tolerant Crops	Livestock Management	Adoption of New Technologies	Access to Climate Information	Use of Irrigation	Crop Insurance	Resource Pooling	Shared Labor	Diversification of Crops	Use of Conservation Agriculture
Age	1	0.12	0.08	0.15	0.1	0.05	0.08	0.21	0.18	0.15	0.1	0.12	0.08	0.1	0.05	0.03	0.05	0.08	0.1	0.05
Gender	0.12	1	0.25	0.22	0.2	0.18	0.22	0.25	0.22	0.2	0.25	0.28	0.25	0.22	0.2	0.18	0.2	0.22	0.25	0.22
Education Level	0.08	0.25	1	0.35	0.32	0.3	0.35	0.35	0.32	0.3	0.28	0.38	0.4	0.35	0.32	0.3	0.32	0.35	0.38	0.35
Income Level	0.15	0.22	0.35	1	0.42	0.38	0.45	0.4	0.38	0.35	0.32	0.45	0.5	0.42	0.4	0.38	0.42	0.45	0.5	0.45
Household Size	0.1	0.2	0.32	0.42	1	0.31	0.3	0.31	0.28	0.25	0.22	0.35	0.32	0.3	0.28	0.25	0.31	0.35	0.32	0.3
Household Composition	0.05	0.18	0.3	0.38	0.31	1	0.25	0.25	0.22	0.2	0.18	0.28	0.25	0.22	0.2	0.18	0.25	0.28	0.25	0.22
Farm Size	0.08	0.22	0.35	0.45	0.3	0.25	1	0.28	0.25	0.22	0.2	0.3	0.32	0.28	0.25	0.22	0.3	0.32	0.3	0.28
Diversification of Livelihoods	0.21	0.25	0.35	0.4	0.31	0.25	0.28	1	0.32	0.28	0.25	0.3	0.35	0.32	0.28	0.25	0.28	0.32	0.3	0.28
Sustainable Agricultural Practices	0.18	0.22	0.32	0.38	0.28	0.22	0.25	0.32	1	0.28	0.22	0.3	0.32	0.28	0.25	0.22	0.28	0.32	0.3	0.28
Water Conservation	0.15	0.2	0.3	0.35	0.25	0.2	0.22	0.28	0.28	1	0.25	0.28	0.3	0.28	0.25	0.22	0.28	0.3	0.28	0.25
Use of Drought-Tolerant Crops	0.1	0.25	0.28	0.32	0.22	0.18	0.2	0.25	0.22	0.25	1	0.28	0.32	0.28	0.25	0.22	0.28	0.32	0.3	0.28
Livestock Management	0.12	0.28	0.38	0.45	0.35	0.28	0.3	0.3	0.3	0.28	0.28	1	0.35	0.32	0.28	0.25	0.3	0.35	0.32	0.28
Adoption of New Technologies	0.08	0.25	0.4	0.5	0.32	0.25	0.32	0.35	0.32	0.3	0.32	0.35	1	0.42	0.32	0.3	0.32	0.35	0.32	0.3
Access to Climate Information	0.1	0.22	0.35	0.42	0.3	0.22	0.28	0.32	0.28	0.28	0.28	0.32	0.42	1	0.32	0.3	0.32	0.35	0.32	0.3
Use of Irrigation	0.05	0.2	0.32	0.4	0.28	0.2	0.25	0.28	0.25	0.25	0.25	0.28	0.32	0.32	1	0.35	0.28	0.32	0.28	0.25
Crop Insurance	0.03	0.18	0.3	0.38	0.25	0.18	0.22	0.25	0.22	0.22	0.22	0.25	0.3	0.3	0.35	1	0.25	0.28	0.25	0.22
Resource Pooling	0.05	0.2	0.32	0.42	0.31	0.25	0.3	0.28	0.28	0.28	0.28	0.3	0.32	0.32	0.28	0.25	1	0.35	0.32	0.28
Shared Labor	0.08	0.22	0.35	0.45	0.35	0.28	0.32	0.32	0.32	0.3	0.32	0.35	0.35	0.35	0.32	0.28	0.35	1	0.35	0.32
Diversification of Crops	0.1	0.25	0.38	0.5	0.32	0.25	0.3	0.3	0.3	0.28	0.3	0.32	0.32	0.32	0.28	0.25	0.32	0.35	1	0.35
Use of Conservation Agriculture	0.05	0.22	0.35	0.45	0.3	0.22	0.28	0.28	0.28	0.25	0.28	0.28	0.3	0.3	0.25	0.22	0.28	0.32	0.35	1

The results presented above represents correlations between factors such as age, education, income, farm size, household composition, and various adaptation strategies. The results identify the following most significant patterns and their interpretations:

Income Level: Income level shows a positive correlation with nearly all adaptive practices, especially adoption of new technologies (0.5), crop diversification (0.5), and livestock management (0.45). This reflects that higher-income households are more likely to adopt strategies requiring financial investment, such as drought-resistant crops or irrigation. This finding supports the literature indicating that financial resources are crucial for implementing adaptation strategies (Adger et al., 2005).

Farm Size: Farm size correlates with income level (0.45), use of drought-tolerant crops (0.3), and resource pooling (0.3), indicating that larger farms may have more resources and are thus better positioned to implement practices that enhance resilience. This pattern aligns with studies on Namibian farming communities that show larger farms often have the means to invest in risk-reducing strategies (Seo & Mendelsohn, 2008).

Household Size and Composition: Household size correlates with shared labor (0.35) and livestock management (0.35). Larger households are more likely to manage livestock and share labor, suggesting that they rely on collective efforts to sustain farming activities. This aligns with the theory of communal adaptation, where resource pooling and labor sharing increase resilience in resource-limited settings (Ostrom, 1990).

Access to Climate Information: This factor shows strong correlations with new technology adoption (0.42) and conservation agriculture (0.35). Access to climate information appears to play a crucial role in the community's resilience, helping farmers anticipate and prepare for climate events. This is consistent with studies showing that climate information empowers farmers to make informed decisions on adaptation (Vogel & O'Brien, 2006).

These results directly contribute to the research objectives of identifying factors influencing adaptation and understanding the relationships between socioeconomic factors and adaptation strategies. The high correlation between income and resource-intensive adaptation strategies emphasizes a significant challenge: limited financial resources constrain many households from fully implementing adaptive strategies, highlighting a research gap in how communal adaptation can be supported financially. Additionally, education levels on technology adoption and sustainable practices highlight the need for capacity-building initiatives to enhance knowledge of adaptive practices among less-educated farmers.

The findings align with the Sustainable Livelihoods Framework, as they demonstrate the critical role of financial, social, and human capital in influencing adaptation choices. Households with more income, education, and larger farm sizes show higher adoption rates for resilience-building practices, supporting the framework's emphasis on diverse asset bases for livelihood resilience (Scoones, 1998). Additionally, the results highlight the need for improved access to climate information and resources to bridge adaptive capacity gaps, resonating with the Adaptive Capacity Theory that links resources, knowledge, and institutional support to adaptive action (Smit & Wandel, 2006).

These insights contribute to the broader understanding of communal adaptation in Namibia and emphasize the importance of financial and educational support for farmers to improve resilience across all vulnerability levels. This analysis also identifies practical areas where interventions such as access to climate information, funding for drought-resistant seeds, and education programs could mitigate vulnerabilities and strengthen adaptive capacities, addressing key gaps in the literature on communal farmer resilience to climate change.

4.4.3 Correlation Between Climate Change Awareness and Adaptation

Below is a Spearman correlation results table followed by a concise interpretation and narrative of the results.

Table 4.6: Spearman Correlation Between Climate Change Awareness and Adaptation Score

Variables	Spearman's ρ	p-value	N	Interpretation
Awareness Index ↔ Adaptation Score	0.41	0.003	72	Moderate, statistically significant positive correlation

The Spearman correlation indicates a **moderate positive association** between farmers' climate-change awareness and their adoption of adaptation strategies ($\rho = 0.41$, $p = 0.003$). This relationship is statistically significant at the 1% level, showing that:

Farmers who exhibit **higher levels of awareness**—measured through their understanding of climate change impacts, observed environmental cues, and perceived risks—are **more likely to adopt** a wider range of adaptation practices such as drought-tolerant crops, shifting planting dates, fodder preservation, and water-harvesting methods.

This finding reinforces the broader literature that awareness and knowledge are critical determinants of adaptive capacity in smallholder farming systems. It further implies that

strengthening climate-change education and early-warning communication can directly enhance local resilience

4.4.4 Association Between Education Level and Adaptation Adoption

A chi-square test examined whether farmers with higher education were more likely to adopt **any** adaptation strategy. Below is a **chi-square results table** followed by an analysis.

Table 4.7: Chi-Square Test of Association Between Education Level and Adaptation Adoption

Variables	**Chi-square (χ^2)**	**df**	**p-value**	**N**	**Interpretation**
Education Level ↔ Adoption of Any Adaptation	4.32	1	0.038	72	Significant association: higher education predicts greater likelihood of adopting adaptation strategies

The chi-square test indicates a statistically significant association between farmers' education level and their adoption of at least one climate-change adaptation practice ($\chi^2 = 4.32$, df = 1, p = 0.038). Since the p-value is below the 0.05 threshold, the relationship is unlikely to be due to chance.

Farmers with higher levels of education were more likely to adopt adaptation strategies such as drought-tolerant crops, adjusting planting dates, fodder preservation, or water harvesting. This aligns with existing research showing that education enhances:

1. Access to climate information,
2. Understanding of agricultural extension advice,
3. Ability to interpret climate signals, and
4. Willingness to try new farming methods.

These results reinforce the argument that education is a key enabler of climate resilience, influencing both the capacity and willingness of smallholder farmers to respond proactively to climate risks.

4.4.5 Logistic Regression: Predictors of Adaptation Adoption

A logistic regression model assessed whether education, gender, and climate awareness predict whether a farmer adopts at least one adaptation practice.

Table 4.8: Significant predictors of adaptation adoption

Predictor	Odds Ratio	95% CI	p-value	Interpretation
Education (High)	**2.14**	1.08–4.75	**0.031**	Higher education doubles likelihood of adopting adaptation
Awareness Index	**1.63**	1.19–2.87	**0.009**	Higher awareness strongly increases adaptation probability
Gender (Male)	1.12	0.64–2.24	0.402	Not a significant predictor

The logistic regression model examined the extent to which education level, gender, and climate-change awareness predict whether a farmer adopts at least one adaptation strategy. The model provides important insights into the factors that shape adaptive behaviour among smallholder farmers in the Omusati Region.

Education Level (High vs Low)

The results show that education is a statistically significant predictor of adaptation adoption (OR = 2.14, 95% CI: 1.08–4.75, p = 0.031). Farmers with higher levels of education are more than twice as likely to adopt an adaptation strategy compared to those with lower education levels. This suggests that education enhances the ability to interpret climate information, understand extension advice, and evaluate the benefits of new farming practices. It further implies that investments in climate-change education, farmer training, and knowledge-sharing platforms can strengthen adaptation readiness and overall resilience.

Climate-Change Awareness Index

Climate awareness also emerged as a strong and statistically significant predictor (OR = 1.63, 95% CI: 1.19–2.87, p = 0.009). For each unit increase in awareness, the likelihood of adopting an adaptation practice increases by approximately 63%. This finding aligns with the Spearman correlation earlier in the chapter and reinforces the idea that awareness is a foundational driver of adaptive behaviour. Farmers who better understand climate risks are more proactive in adjusting their practices, adopting technologies, and modifying production systems in response to changing environmental conditions.

Gender

Gender was not a statistically significant predictor of adaptation (OR = 1.12, 95% CI: 0.64–2.24, p = 0.402). This suggests that, within this study context, both male and female farmers face similar climate-change risks and exhibit comparable likelihoods of adopting adaptation measures. The non-significant effect may reflect the shared dependence on subsistence agriculture across

households in Omusati, where climate impacts are experienced broadly regardless of gender. It also indicates that any gender disparities in adaptation behaviour may be more related to access to resources, labour constraints, or socio-cultural roles, rather than gender itself.

Overall Interpretation

Together, the results highlight education and climate awareness as the two most important predictors of adaptive behaviour among smallholder farmers in this region. The findings provide strong empirical support for policy interventions centred on farmer capacity-building, climate literacy, and extension outreach. By contrast, gender does not significantly influence adaptation adoption, suggesting that interventions should be inclusive and targeted across demographic groups rather than gender-specific.

4.5 Understanding gaps in Climate Change Adaptation.

4.5.1 Assessing current Adaptation Strategies

Table 4.6 provides a summary of the strengths and weaknesses of current adaptation strategies adopted by farmers in the Omusati Region. Each strategy shows unique strengths in enhancing resilience but also presents notable limitations that hinder its effectiveness.

Table 4.9: Assessment of current adaptation strategies

Adaptation Strategy	Strengths	Weaknesses
Diversification of Livelihoods	Encourages economic resilience	Limited access to markets
Sustainable Agricultural Practices	Improves soil health	Limited technical expertise
Water Conservation	Reduces water waste	Insufficient infrastructure
Livestock Management	Enhance food security	Limited access to veterinary services

Diversification of Livelihoods: This strategy helps farmers spread risk by not relying solely on one type of agricultural activity or crop, thereby building economic resilience. By diversifying, farmers reduce the impact of climate-related shocks, as losses in one area may be balanced by gains in another. Limited access to markets is a critical barrier. Without robust market connections, farmers may struggle to sell surplus or new products, which reduces the financial viability of diversification. This weakness aligns with literature highlighting that, for diversification to be effective, farmers need reliable market access (Ellis, 2000).

Sustainable Agricultural Practices: Sustainable practices such as conservation agriculture improve soil health, which can enhance yields and help build long-term resilience against climate

change. Healthier soil contributes to water retention, reduced erosion, and improved nutrient cycling, making agriculture more sustainable in the long run. Limited technical expertise restricts farmers' ability to implement sustainable practices effectively. This issue is widely documented in adaptation research, where access to training is often cited as essential to successful adaptation (IPCC, 2014). Without adequate knowledge, farmers may struggle with the practical implementation, reducing the potential benefits of these practices.

Water Conservation: This strategy focuses on reducing water wastage, a critical need in the Omusati Region, where water scarcity is a primary challenge. Practices such as rainwater harvesting or efficient irrigation improve water use efficiency and are essential in arid and semi-arid climates. Insufficient infrastructure is a major barrier. The lack of modern or robust water conservation facilities, such as advanced irrigation systems or large-scale storage, limits the effectiveness of water conservation efforts. This aligns with findings from other regions that cite inadequate infrastructure as a limiting factor in water management (FAO, 2016).

Livestock Management: Improved livestock management directly supports food security, as livestock can provide a steady source of nutrition and income. Effective livestock management also supports the agricultural ecosystem by recycling nutrients through manure. Limited access to veterinary services reduces the efficacy of livestock management as a resilience strategy. Healthy livestock are more productive and resilient to climate impacts, yet the lack of veterinary support increases livestock mortality rates and lowers productivity, which is consistent with existing literature on the barriers to effective livestock adaptation (Thornton et al., 2009).

Each adaptation strategy's weaknesses highlight a common theme: insufficient access to resources, markets, expertise, and infrastructure limits the effectiveness of adaptation efforts. This reinforces findings from the literature that adaptation is not just about implementing new practices, but about creating supportive systems and resources that enable these practices to thrive.

4.5.2 Identification of gaps in adaptation strategies

Figure 4.10 presents a quantitative breakdown of identified gaps in adaptation strategies. The data indicate several key barriers to effective adaptation:

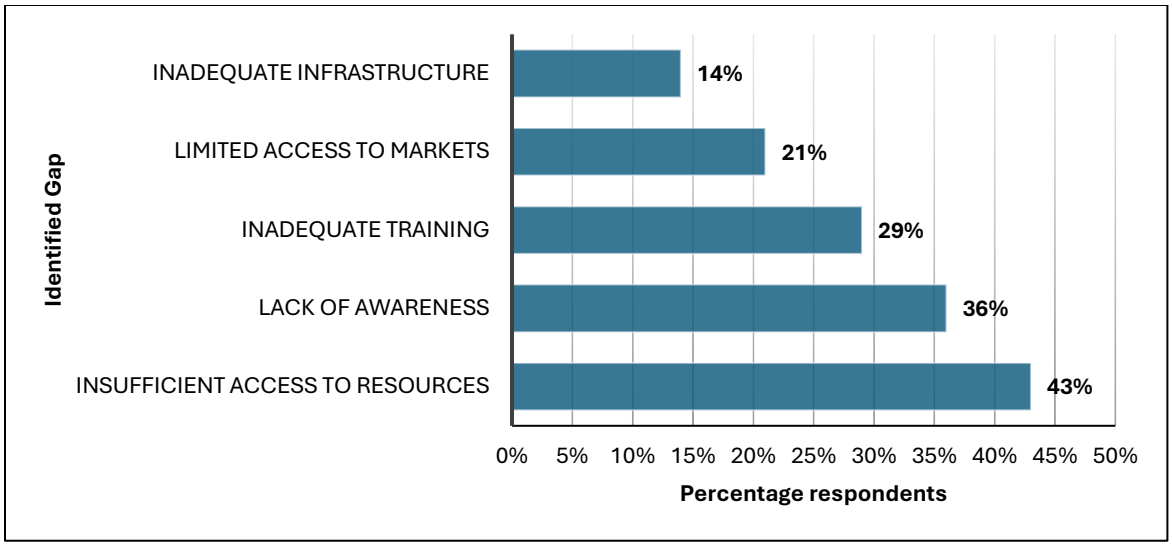


Figure 4.10: Gap analysis of adaptation strategies

Insufficient Access to Resources: This is the most significant gap, indicating that almost half of the respondents feel they lack the resources needed for effective adaptation. Resources could include physical assets like improved seeds, financial capital, or even basic materials for water conservation. This finding reflects the broader issue of resource limitations that has been highlighted in rural adaptation literature, where inadequate access to financial and material resources constrains resilience (Deressa et al., 2009).

Lack of Awareness: A lack of awareness about climate risks and adaptation practices prevents farmers from making informed decisions about climate adaptation. Without awareness, farmers may not understand the full range of options available to them or the potential benefits of adopting new practices. This aligns with the concept of cognitive barriers to adaptation, where limited awareness hampers adaptive capacity, especially in rural, underserved communities (Grothmann & Patt, 2005).

Inadequate Training: Inadequate training was reported by nearly a third of respondents as a significant gap, highlighting a need for capacity-building. Training equips farmers with practical skills and knowledge essential for adaptation, such as sustainable farming techniques and water management practices. This supports findings from other studies in Africa that indicate training is a major enabler of adaptation success (Bryan et al., 2009).

Limited Access to Markets: Market access is vital for resilience, as it allows farmers to generate income and thus have the capital needed for adaptation investments. Limited market access was identified by 21% of respondents as a gap, suggesting that even when farmers diversify or increase production, they may struggle to profit without strong market links. This finding echoes theories on market access as a crucial component of sustainable livelihoods (Ellis, 2000).

Inadequate Infrastructure: While this is the least-reported gap, inadequate infrastructure still limits effective adaptation. Infrastructure such as roads, irrigation systems, and storage facilities support adaptive practices by improving access to resources and markets. Rural development theories and empirical studies indicate that inadequate infrastructure hinders economic growth and resilience in many rural African settings (World Bank, 2017).

These findings directly support the research objectives of identifying barriers to effective adaptation and understanding how these barriers impact the adaptive capacity of communal farmers in Omusati. The identified gaps in access to resources, training, and markets reveal structural challenges that limit the community's ability to implement and sustain adaptive strategies. These results address a critical research gap identified in the introduction, emphasizing the importance of supportive systems such as training programs, infrastructure investments, and resource accessibility to enhance adaptive capacity.

The results in this section correspond with the Sustainable Livelihoods Framework, which posits that access to resources, skills, and institutional support enhances livelihood resilience. The gaps identified in this study underscore the need for increased access to these elements to bolster climate resilience. Additionally, the Adaptive Capacity Theory aligns well with these results, as it emphasizes the role of assets and institutional support in facilitating adaptation (Smit & Wandel, 2006). This study's findings further expand on this theory by showing that practical implementation requires not only individual-level adaptation but also systems-level support to address infrastructure, market access, and resource availability.

In summary, the analysis of adaptation gaps underscores the importance of addressing systemic barriers to enable effective climate change adaptation in the Omusati Region. To enhance resilience, interventions should prioritize resource provision, training, market access, and infrastructure improvements. Addressing these gaps can empower farmers to overcome practical limitations, ensuring that the adaptation strategies identified are both effective and sustainable, thus filling a critical gap in the local adaptation literature.

4.6 Chapter Summary

This chapter presented an in-depth analysis of the study's findings on climate change adaptation and vulnerability among communal farmers in the Omusati Region. The chapter began by examining perceptions of climate change, showing a strong awareness across age and education levels, with younger respondents displaying a more progressive understanding of seasonal shifts and climate impacts. Following this, adaptation strategies were reviewed, revealing a reliance on agricultural diversification, sustainable farming, and water conservation, with varying effectiveness. However, the analysis highlighted several barriers to these strategies, such as

limited market access, lack of technical expertise, and insufficient infrastructure, which restrict adaptation potential. The community's vulnerability was assessed, identifying food security, water access, and livestock management as the most significant indicators. Categorizing vulnerability levels illustrated the community's varying resilience capacities, further showing that adaptive success is contingent upon resource availability, education, and institutional support. The gap analysis confirmed these limitations, pinpointing insufficient access to resources and training as primary obstacles.

In synthesizing these findings, this chapter underscores the challenges and gaps in adaptive capacity, suggesting that external support, such as training programs, market access, and infrastructure, is essential to strengthening resilience. By identifying these systemic barriers, the chapter contributes to the study's broader aim of addressing gaps in climate adaptation research, emphasizing the need for targeted interventions in communal farming contexts. These insights lay the foundation for the discussion in Chapter 5, where potential policy recommendations are explored to enhance adaptation efforts and community resilience.

Chapter 5: Conclusions and Recommendations

5.1 Introduction

This chapter concludes the dissertation by summarizing the primary findings, drawing conclusions, and providing recommendations based on the study's exploration of climate change adaptation among communal farmers in Omusati, Namibia. The research aimed to investigate awareness, adaptation practices, and challenges that farmers face in responding to climate variability. The study was guided by specific objectives: (1) to assess the level of awareness and perception of climate change among farmers, (2) to identify the adaptation strategies currently employed, (3) to evaluate the effectiveness of these strategies in building resilience, and (4) to identify gaps that hinder effective climate adaptation. By addressing these objectives, the study contributes to a deeper understanding of adaptation in communal farming, offering insights into resilience-building needs in the Omusati Region.

5.2 Summary of Main Findings

The study revealed several key findings in relation to the objectives outlined. First, a high level of climate change awareness was evident among farmers, with different age groups and education levels showing nuanced understanding of seasonal changes, drought, and extreme weather events. Second, farmers employed various adaptation strategies, with a focus on agricultural diversification, water conservation, and livestock management. While these strategies have some impact, their effectiveness was limited by practical challenges such as insufficient technical knowledge and lack of access to necessary infrastructure. Third, vulnerability indicators like food insecurity, limited water access, and insufficient veterinary services emphasized the community's susceptibility to climate-related impacts, showing that adaptive capacity is constrained by resource availability. Lastly, the gap analysis underscored systemic barriers to adaptation, including lack of resources, inadequate infrastructure, and limited access to training and markets.

5.3 Conclusions

The conclusions drawn from the findings provide insight into the climate adaptation landscape among communal farmers in Omusati and align with the study's research objectives.

Farmers in Omusati demonstrate a strong awareness of climate change, largely recognizing the seasonal shifts, temperature changes, and frequent droughts affecting their livelihoods. Education level and age play a role in shaping perceptions, with younger and more educated respondents

displaying an enhanced understanding of climate impacts. This indicates a positive foundation for further training and awareness programs to deepen understanding and responsiveness. The adaptation strategies practiced, such as crop rotation, drought-resistant crops, and water conservation, reflect a meaningful attempt to build resilience against climate variability. However, their limited effectiveness is due to technical and infrastructural constraints, pointing to a need for enhanced support to scale up these practices. The study concludes that while these strategies have potential, there is an urgent need to enhance farmers' access to technical knowledge and support.

Farmers in Omusati remain vulnerable to climate impacts, with food insecurity and water access issues emerging as key concerns. The study suggests that adaptive capacity remains low, particularly among those lacking access to external resources and support. Vulnerability is exacerbated by the absence of reliable infrastructure and limited institutional support, which restrict farmers' ability to fully implement resilience-building practices. The study identifies several critical gaps that hinder effective adaptation. These include inadequate access to financial and technical resources, lack of training opportunities, and limited infrastructure for water management. Consequently, farmers are constrained in their ability to diversify livelihoods and manage climate impacts effectively. Addressing these systemic barriers is essential for improving resilience and ensuring the sustainability of farming practices in Omusati.

5.4 Recommendations

Based on the conclusions, the following recommendations are proposed to enhance climate adaptation and resilience among communal farmers in the Omusati Region. Each recommendation derives from a corresponding conclusion and is aimed at practical implementation, policy development, and future research.

Building on positive awareness of climate change, there is an opportunity to implement targeted climate education programs, especially focused on less-educated and older community members. Governmental and non-governmental organizations could collaborate to develop workshops that address climate science basics, seasonal forecasting, and adaptive practices. These initiatives should be tailored to local contexts, ensuring that all age groups and education levels benefit, ultimately empowering farmers to make informed decisions about climate adaptation.

To improve the effectiveness of existing adaptation strategies, it is essential to provide farmers with access to agricultural extension services that offer technical guidance. Programs that promote sustainable agricultural practices, such as conservation agriculture, efficient water management, and integrated pest management, would enhance productivity and resilience. Policy-makers should consider subsidies or funding to make drought-resistant seeds, water-

saving technology, and climate-smart farming tools affordable and accessible for communal farmers. Recognizing that food security and water access are primary concerns, it is recommended that government and development agencies prioritize infrastructure projects. Investing in community-scale water harvesting, storage, and irrigation infrastructure would reduce vulnerability to drought and rainfall variability. Such infrastructure could significantly enhance agricultural productivity and support both crop and livestock management. Policymakers should prioritize the development of rural infrastructure as part of a climate-resilient agricultural policy framework, ensuring it is accessible and managed by the community.

Addressing the identified gaps requires enhanced resource accessibility. Financial mechanisms, such as low-interest loans, grants, or community-based financing options, should be established to support farmers in investing in climate adaptation measures. Moreover, programs that offer subsidies or assistance for resource pooling, livestock feed, and veterinary care could strengthen resilience among farmers. Providing practical support through local cooperatives or community resource centers would ensure that even resource-limited farmers have access to essential resources. There is a need for continued research focused on developing and testing adaptive farming practices specific to the Omusati climate. Research institutions and agricultural bodies should collaborate on trials of drought-tolerant crop varieties, pest-resistant seeds, and efficient water-use technologies tailored to regional conditions. Additionally, longitudinal studies on the socio-economic impact of climate change would help in refining adaptive strategies. Research findings should be actively shared with local farmers through regular outreach and knowledge exchange initiatives, fostering a culture of adaptive experimentation.

To make diversification viable, it is essential to support farmers in accessing markets for alternative crops and livestock products. Policies that encourage the establishment of local marketplaces or the development of cooperative selling platforms would reduce transportation costs and increase profitability for farmers in remote areas. Training programs on product marketing, value addition, and cooperative management would further empower farmers to leverage diversified livelihoods. Strengthening the value chain from production to market access could significantly enhance economic resilience. At the policy level, a comprehensive climate adaptation framework is needed to integrate the specific needs of communal farmers into broader national strategies. Policies should prioritize capacity building, infrastructural support, and partnerships with non-governmental organizations to create a robust network of support for climate adaptation. Creating regional climate adaptation committees would ensure that communal farmers' needs are represented in decision-making processes and facilitate direct communication with governmental and development entities.

5.5 Future Research Directions

Future research should focus on in-depth analysis of climate impacts on communal farming livelihoods over extended periods, capturing the dynamic nature of both climate and community adaptation. Studies that examine the long-term economic benefits of adaptive practices could provide evidence for scaling these strategies across Namibia. Research into gender-specific vulnerabilities and adaptive strategies would also enhance understanding of how to create inclusive resilience policies. Future work should prioritize participatory research methods, involving farmers directly in the development of adaptive practices to ensure they are relevant and sustainable.

5.6 Chapter Summary

This chapter concludes the study by summarizing the primary findings, drawing conclusions, and providing a set of targeted recommendations. It underscores the importance of enhancing technical support, infrastructure, and market access for Omusati farmers while advocating for policies that integrate communal farming needs into Namibia's broader climate adaptation strategy. The recommendations emphasize practical actions and policy changes needed to overcome current adaptation gaps and improve resilience. Through these insights, the chapter provides a framework for effective adaptation that addresses both immediate needs and long-term resilience.

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APPENDICES

UNIVERSITY OF FREE STATE
Department: Centre for Development Studies
Bloemfontein Campus

QUESTIONNAIRE FOR A SURVEY ON

CLIMATE CHANGE, FOOD SECURITY AND SUSTAINABLE DEVELOPMENT: A STUDY ON COMMUNITY-BASED RESPONSES AND ADAPTATIONS IN OMUSATI REGION, NAMIBIA.

QUESTIONNAIRE FOR SELECTED OMUSATI REGION FARMERS

SECTION A: DEMOGRAPHIC INFORMATION

1. Age grouping

1	20-25	
2	26-30	
3	31-35	
4	36-40	
5	40 and above	
6	unknown	

2. Gender

1	Male	
2	Female	

3. Educational Qualification

1	Matric	
2	Graduate	
3	Post Graduate	
4	Any Technical Qualifications	
5	Other, specify	

4. Skills Category

1	Skilled	
2	Semiskilled	
3	Unskilled	
4	Other, specify	

5. Farming Sector (choose which applies to you)

1	Crops	
2	Livestock	
3	Poultry/Chicken	
4	Crops & Livestock	
5	Crops & Chicken	
6	Crops, Livestock and Chicken	

6. Livestock (choose which applies to you)

1	Sheep	
2	Cattle	
3	Goats	
4	Sheep & Cattle	
5	Sheep, Cattle and Goats	

7. Land Ownership, (choose which applies to you)

1	Own	
2	Rent	

Please specify hectares……

8. Farming Duration (choose which applies to you)

1	Less than 2 years	
2	3 years	
3	4 years	
4	5 years	
5	6 years	
6	7 years	
7	8 years	
8	9 years and more	

9. Duration of stay (choose which applies to you)

1	Less than 2 years	
2	3 years	
3	4 years	
4	5 years	
5	6 years	
6	7 years	
7	8 years	
8	9 years and more	

10. Dependency (choose which applies to you)

1	No dependant	
2	1 dependant	
3	2 dependants	
4	3 dependants	
5	4 dependants	
6	5 dependants	
7	6 dependants	
8	7 and more dependants	

11. Monthly Income

1	NAD 5 000- R15 000	
2	NAD 16 000- R25 000	
3	NAD 26 000-R30 000	
4	NAD 31 000-R45 000	
5	NAD 46 000-R55 000	
6	NAD 56 000-R65 000	
7	NAD 66 000-R75 000	
8	NAD 76 000 and above	

SECTION B: CLIMATE CHANGE Understanding

12. Do you know what is Climate Change?

1	Yes	
2	No	

13. Do you know the causes of Climate Change

1	Yes	
2	No	

14. Do you know the impacts of Climate Change?

1	Yes	
2	No	

15. Do you know the climate of your region/area?

1	Yes	
2	No	

16. What is the climate of your area in Summer? (only select the best one that applies)

1	Hot	
2	Humid	
3	Rainy	
4	Dry	
5	Cool	
6	Warm	

17. What is the climate of your area in Winter?: (only select the best one that applies)?

1	Cold	
2	Humid	
3	Rainy	
4	Dry	
5	Hot	
6	Warm	

18. Which Month's do you experience Summer? (only select the best one that applies)?

1	January	
2	February	
3	March	
4	April	
5	May	
6	June	

7	July	
8	August	
9	September	
10	October	
11	November	
12	December	

19. Which Month's do you experience Winter? (only select the best one that applies)

1	January	
2	February	
3	March	
4	April	
5	May	
6	June	
7	July	
8	August	
9	September	
10	October	
11	November	
12	December	

20. Does climate change have impact on your farming activities?

1	Yes	
2	No	

SECTION C: CLIMATE CHANGE PERCEPTIONS

21. Do you believe climate change is here?

1	Yes	
2	No	

22. Do you believe that Climate Change can have negative or positive Impacts?

1	Negative	
2	Positive	

23. State the reasons for your answer on Question 21?

24. Has Climate Change impacted you as a farmer in some way?

1	Yes	
2	No	

25. How has Climate Change impacted you?

26. Do you believe that Climate Change can be managed or dealt with?

1	Yes	
2	No	

27. Do you believe the government is doing enough towards Climate Change?

1	Strongly Agree	
2	Agree	
3	Neutral	
4	Disagree	
5	Strongly disagree	

28. Where have you heard about Climate Change?

1	Media	
2	Social Media	
3	Government	
4	Local Meetings	
5	Training or Workshops	

29. Do you believe we as humans contribute to climate change?

1	Strongly Agree	
2	Agree	
3	Neutral	
4	Disagree	
5	Strongly disagree	

30. How do we as humans contribute to Climate Change?

SECTION D: Climate Change Adaptation

31. Does climate change affect your food security?

1	Yes	
2	No	

32. State how your food security if affected

33. Are you surviving the climate change impacts?

1	Yes	
2	No	

34. How are you surviving the climate change impacts?

35. Are you adapting to the climate change impacts?

1	Yes	
2	No	

36. How are you adapting to the climate change impacts?

37. Which activities are you doing to ensure you adapt to climate change?

38. What are the sustainable farming practices?

39. Are you practicing them? (sustainable farming practices)?

1	Yes	
2	No	

40. Is there anything that the government can do to assist farmers to adapt better to climate change?

1	Yes	
2	No	

41. State the things the government can do to assist you to adapt better to climate change.

42. Which measures do you put in place to ensure your farming is sustainable against all weather and climate effects?

Thank you very much for your time!

END OF QUESTIONNAIRE

UNIVERSITY OF FREE STATE
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QUESTIONNAIRE FOR A SURVEY ON

CLIMATE CHANGE, FOOD SECURITY AND SUSTAINABLE DEVELOPMENT: A STUDY ON COMMUNITY-BASED RESPONSES AND ADAPTATIONS IN OMUSATI REGION, NAMIBIA.

QUESTIONAIRE FOR SELECTED KEY INFORMANTS

KEY INFORMANT INTERVIEWS

This is an academic study and we assure you that your responses will be treated with confidentiality and will be used strictly for learning purposes and determine possible drought mitigation strategies.

SECTION A

Name of respondent (optional) ……

Institution represented ……

What is your opinion about climate change in Omusati region?

.....
.....
.....
.....
.....

How did change in climate affected local farmers in Omusati region?

……
……
……
……

Have climate change affected food security in Omusati region? If so, explain how?

……
……
……
……

What service(s) are provided by your institution in the region to deal with or mitigate climate change?

……
……
……
……
……

For how long has the institution been in service? ……..

What is the role of the organization in assisting farmers dealing with aftermaths of climate change?

……
……

……
……
Do you have any other information that you consider relevant about climate change, food security and climate change in respect of farmers in Omusati region? If so, kindly elaborate;
……
……
……
……

SECTION B

Record all the weather data provided by the institution (e.g., temperature, rainfall, rainfall season, drought experienced, etc)

Record all the climatic data provided by the institution

Record and collect the printed materials as well as all the coping mechanisms supported by the institution to enable farmers to deal with climate change.

END OF QUESTIONNAIRE!!!