



**THE IMPACTS OF CLIMATE CHANGE AND DROUGHT ON SMALLHOLDER
FARM PRODUCTIVITY IN THE OVERBERG DISTRICT MUNICIPALITY, SOUTH
AFRICA**

By

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Thesis submitted in fulfilment of the requirements of the degree

Master of Environmental Health

in the Faculty of Applied Sciences

at Cape Peninsula University of Technology

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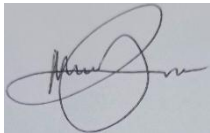
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DECLARATION

I, Pitso Hemly Mashile, declare that the contents of this thesis represent my unaided work, and that the thesis has not previously been submitted for academic examination towards any qualification. Furthermore, it represents my own opinions and not necessarily those of the Cape Peninsula University of Technology.



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ABSTRACT

Climate change is among the major problems facing the agricultural sector today. This thesis has assessed the impact of climate change and drought on water availability and the resultant effect on smallholder farm productivity in the Overberg District Municipality. A sustainable livelihood framework was used to design and formulate the study. This study adopted a mixed-methods approach. Data were collected from 100 smallholder farmers using a survey questionnaire. The questionnaire was supplemented with six focus group discussions to follow up on identified issues and to expand the scope of data collection. Further, semi-structured interviews were conducted with 13 key informants from key local institutions related to water and agriculture. Descriptive statistics and thematic analysis were used to analyse quantitative and qualitative data, respectively. The study revealed that most smallholder farmers noticed an increase in temperature (68%), rainfall (51%) and exposure to extreme weather events, including floods (33%), droughts (29%), storms (15%), forest fires (12%), and heatwaves (11%). Drought was perceived as a major stressor that caused agricultural water shortages. As a result of extreme weather events, smallholder farmers experienced a decline in crop yields and loss of livestock. In response to climate shocks, smallholder farmers implemented strategies to reduce the negative effects on their farming. The reported coping strategies included transporting water to farms (33%), receiving government relief (26%), purchasing animal feed (9%), relocating the farm (9%), reducing livestock numbers (5%), and limiting irrigation (5%). Main adaptation strategies included building livestock shelters (18%), digging flood channels (18%), crop-shedding (16%), and creating fire breaks (14%). Using greywater (9%), rainwater harvesting (6%), taking insurance (6%), buying water tanks (6%), mulching (3%) and composting were the least-used strategies (3%). About 37% of smallholder farmers did not implement any strategy. Lack of funding (40%), water shortages (22%), lack of support (17%), and inadequate farming equipment (12%) were the primary factors preventing smallholder farmers from adopting effective climate adaptation strategies. Smallholder farmers in this study were vulnerable to the changing climate, exacerbated by their lower adaptive capacity. The smallholder farmers outlined several strategies that they are willing to implement in future to adapt to water shortage. This included the purchase of water tanks, drilling boreholes, building dams, cultivating feed, taking insurance covers, and changing planting dates. However, smallholder farmers need support from relevant government departments, voluntary organisations, and private players to adapt effectively to climate change. This study also recommends training farmers on adaptation to strengthen their capacity.

Keywords: Smallholder farmers, climate change, drought, floods, adaptation

ACKNOWLEDGEMENTS

The research was funded by the Water Research Commission (Project No. C2022/2023-00845). Private Bag X03, Gezina, 0031, South Africa. This work is based on the research supported in part by the National Research Foundation of South Africa (Grant Number 142208). Opinions expressed in this thesis and the conclusions arrived at, are those of the author, and are not necessarily to be attributed to the Water Research Commission and the National Research Foundation.

I wish to extend my gratitude to:

- Prof. Bongani Ncube, my supervisor, for her guidance and support in completing and securing the funding for this study.
- Dr Evans Shoko, my co-supervisor, for the guidance and support he gave throughout the study.
- Mr Kudzai Mugejo and Mr Aphiwe Manyike for all the support I received from them during fieldwork.
- All the Officers from the Department of Agriculture in Overberg District, who made it possible for us to meet with smallholder farmers and interview them.
- Smallholder farmers who agreed to be interviewed made it possible for me to complete this study.

DEDICATION

I dedicate this thesis to my lovely wife, Ofentse Lekukela, and to my daughter Remuneilwe Mashile, who have been my source of motivation.

RESEARCH OUTPUTS

Journal Article

Mashile, P. H., Shoko, E., & Ncube, B. 2025. Drought and flood impacts on agricultural water availability in smallholder farms in the Overberg District, Western Cape Province, South Africa. *Interdisciplinary Journal of Rural and Community Studies*, 7(2): 1-18. <https://doi.org/10.38140/ijrcs-2025.vol7.2.06>

Conference presentations

Mashile, P.H., Ncube, B. & Shoko, E. 2024a. The impacts of climate change on smallholder farm productivity in the Overberg District Municipality, South Africa. *U6 International Conference – Research, Innovation, and Technology for Africa*. Cape Peninsula University of Technology, Cape Town, South Africa. July 2024.

Mashile PH., Ncube B., and Shoko E. 2024b. Understanding the Effects of Climate Change on Agricultural Production in Smallholder Farms in the Overberg District, Western Cape. The South African Institute of Agricultural Engineers and 6th Pan African Society for Agricultural Engineering International Symposium. 23 – 25 October 2024. Houw Hoek, Grabouw, South Africa.

TABLE OF CONTENTS

DECLARATION	ii
ABSTRACT.....	iii
ACKNOWLEDGEMENTS	iv
DEDICATION.....	v
RESEARCH OUTPUTS	vi
List of Figures	xi
List of Tables	xiii
GLOSSARY	xiv
ACRONYMS AND ABBREVIATIONS	xvi
CHAPTER ONE: INTRODUCTION AND BACKGROUND	1
1.1 Introduction and background to the study.....	1
1.2 Problem statement	3
1.3 Delineation of the study.....	4
1.4 Justification for the study	5
1.5 Research questions.....	5
1.6 Aim and objectives of the study.....	5
1.7 Structure of the dissertation.....	6
1.8 Chapter conclusion.....	6
CHAPTER TWO: Literature Review	8
2.1 Introduction	8
2.2 Defining smallholder farming	8
2.3 Conceptual framework	10
2.3.1 Vulnerability context	12
2.3.2 Livelihood assets.....	12
2.4 Benefits and limitations of a sustainable livelihood framework.....	14
2.5 International literature on the impacts of climate change on smallholder agriculture..	16
2.6 A review of climate change and drought impacts on smallholder farmers in South Africa	
.....	20
2.6.1 Impact on water resources	20
2.6.2 Impacts on crop production	21
2.6.3 Impacts on livestock	23
2.6.4 Socioeconomic impacts.....	24
2.7 A general review of coping and adaptation strategies.....	27
2.7.1 Review of adaptation and coping strategies for crop production	28
2.7.2 Adaptation and coping strategies for livestock.....	29

2.8 Constraints for adaptation	30
2.9 Chapter summary and conclusion	32
CHAPTER THREE: Research design and methodology	33
3.1 Introduction	33
3.2 The study area	33
3.3 Research design	34
3.3.1 Quantitative research design	35
3.3.2 Qualitative research design	35
3.4 Data collection procedure and instruments.....	37
3.4.1 Survey questionnaire.....	37
3.4.2 Focused Group Discussion.....	38
3.4.3 Semi-structured interviews	38
3.5 Sampling.....	39
3.7 Data analysis.....	41
3.7.1 Familiarise with data.....	41
3.7.2 Generate codes.....	41
3.7.3 Search for themes	42
3.7.4 Review themes.....	42
3.7.5 Define and name themes.....	42
3.7.6 Write a report.....	42
3.8 Data reliability, validity, and trustworthiness	42
3.8.1 Credibility	42
3.8.2 Confirmability.....	43
3.8.3 Transferability.....	43
3.8.4 Dependability.....	43
3.9 Ethics statement.....	43
3.10 Limitations of the study.....	45
3.11 Chapter conclusion.....	45
CHAPTER FOUR: Findings and Discussion	46
4.1 Introduction	46
4.2 Characteristics of smallholder farmers.....	46
4.2.1 Age.....	46
4.2.2 Gender	48
4.2.3 Household sizes	49
4.2.4 Level of education	50
4.2.5 Years of farming	51
4.2.6 Land sizes	52

4.2.7 Land tenure	52
4.2.8 Types of farming.....	54
4.2.8 Primary purpose of farming	55
4.2.9 Adequacy of farming land	56
4.2.10 Farming methods.....	56
4.2.11 Access to credit	57
4.3 Smallholder farmer climate change perceptions	58
4.3.1 Understanding of climate change and drought.....	58
4.3.2 Climate change and drought information sources	59
4.3.3 Perceptions of rainfall and temperature	60
4.3.4 Temperature and rainfall measurements	62
4.3.5 Other climate change-related events	63
4.4 Effects of climate change and drought on agricultural water availability.....	63
4.4.1 Water sources	63
4.4.2 Water use access mechanisms	64
4.4.3 Cost of agricultural water	65
4.4.4 Affordability of agricultural water	66
4.4.5 Climate change and drought impact on agricultural water availability	67
4.5 Climate change and drought effects on smallholder farming	71
4.5.1 Effects on the productivity of smallholder farmers.....	71
4.5.2 Impacts of climate change and drought on smallholder farmers' livelihood	75
4.5.3 Impacts of climate change and drought on the well-being of farmers.....	78
4.6 Smallholder farmers' response to climate change and drought	80
4.6.1 Coping strategies	80
4.6.2 Adaptation strategies.....	81
4.6.3 Challenges faced in coping and adapting to the effects of climate change and drought.....	82
4.6.4 Perceptions of future adaptation.....	83
4.6.5 Institutional support	84
4.7 Other challenges for smallholder farmers	86
4.8 Support needed by farmers	87
4.9 Implications of the results for the livelihood capitals of smallholder farmers	88
4.9.1 Financial capital.....	88
4.9.2 Human capital	89
4.9.3 Natural capital	89
4.9.4 Social capital	90
4.9.5 Physical capital.....	90

CHAPTER FIVE: Conclusion and recommendations	91
5.1 Conclusion	91
5.2 Recommendations	93
5.3 Future research.....	95
References	96
APPENDICES.....	109

LIST OF FIGURES

Figure 2.1: Sustainable livelihoods framework	11
Figure 3.1: Map showing the study area.....	34
Figure 4.1: Age grouping of smallholder farmers in Overberg District (n=100)	48
Figure 4.2: Gender distribution of farmers in Overberg District (n=100).....	49
Figure 4.3: Household sizes of smallholder farmers in Overberg District (n=100)	50
Figure 4.4: Smallholder farmers' level of education in Overberg District (n=100)	49
Figure 4.5: Years of involvement in farming for smallholder farmers in Overberg District (n=100)	51
Figure 4.6: Land size distribution among smallholder farmers in Overberg District (n=100)	52
Figure 4.7: Smallholder farmers' means of land ownership in Overberg District (n=100).....	53
Figure 4.8: Distribution of lease agreement among smallholder farmers (n=100).....	54
Figure 4.9: Smallholder farming practices in Overberg District (n=100).....	55
Figure 4.10: Smallholder farmers' purpose of farming in Overberg District (n=100).....	55
Figure 4.11: Farming methods among smallholder farmers (n=100)	57
Figure 4.12: Smallholder farmers' status on access to credit (n=100)	58
Figure 4.13: Distribution of participants' understanding of drought (n=100).....	58
Figure 4.14: Distribution of participants' understanding of climate change (n=100)	59
Figure 4.15: Smallholder farmers' perceptions of temperature and rainfall changes (n=100)	61
Figure 4.16: Smallholder farmers' measurement of temperature and rainfall (n=100)	62
Figure 4.17: Smallholder farmers' mechanisms for accessing agricultural water (N=100) ...	65
Figure 4.18: Cost of agricultural water (N=100).....	66
Figure 4.19: Smallholder farmers' perceptions on agricultural water availability (n=100).....	67
Figure 4.20: Impact of drought on agricultural water availability	70
Figure 4.21: Impacts of floods on water resources	71
Figure 4.22: Distribution of impacts of climate change and drought on the livelihood of smallholder farmers	78
Figure 4.23: Distribution of impacts of climate change and drought on the well-being of smallholder farmers	79
Figure 4.24: Distribution of coping strategies adopted by smallholder farmers (N=100)	81
Figure 4.25: Distribution of adaptation strategies adopted by smallholder farmers (N=100)	82
Figure 4.26: Perceived challenges to coping with climate disasters (N=100).....	83
Figure 4.27: Smallholder farmers' perceptions on future adaptation (N=100).....	84
Figure 4.28: Smallholder farmers' perceptions of institutional support (N=100)	86
Figure 4.29: Distribution of other challenges faced by smallholder farmers	87

Figure 4.30: Various supports needed by smallholder farmers..... 88

LIST OF TABLES

Table 2.1: Impact of climate change identified by smallholder farmers in South Africa	27
Table 4.1: Various sources of climate change and drought information.....	60
Table 4.2: Climate-related disasters experienced by smallholder farmers (n=100).....	63
Table 4.3: Smallholder farmers' agricultural water sources (n=100)	64
Table 4.4: Impact of climate disasters on smallholder farm productivity (N=100)	75

GLOSSARY

Climate change – The Intergovernmental Panel on Climate Change (IPCC, 2021) defined climate change as a statistically significant change in climate properties for an extended period, normally for a decade or longer.

Drought - refers to an extended period of rainfall deficiency (Botai et al., 2017).

Smallholder farmers – The South African Department of Agriculture, Forestry and Fisheries (DAFF, 2015) defined smallholder farmers as *“farmers who produce for household consumption and market, subsequently earning an ongoing revenue from the farming businesses, which form a source of income for the family. The farmers have the potential to expand their operations and to become commercial farmers, but need access to comprehensive support.”* In this study, ‘smallholder farmers’ referred to resource-poor farmers engaged in small-scale farming. They were mostly practising on land with a size of less than a hectare.

Agricultural water – refers to water used for farming activities, such as livestock and crop irrigation.

Food security – means having access to sufficient food to meet daily household needs (Mafongoya et al., 2022).

Water security - refers to sustainable access to sufficient quality water for domestic, industrial, or agricultural purposes (World Bank, 2021).

Vulnerability – Serrat (2017) defined the term ‘vulnerability’ as “insecurity in the well-being of individuals, households, and communities in the face of changes in their external environment”. The term vulnerability in this study describes the likelihood of smallholder farmers being affected by climate hazards.

Adaptation strategies are long-term strategies adopted because of a shock to minimise the impacts (Osman-Elasha et al., 2005). In this study, adaptation refers to the ability of smallholder farmers to build resilience to current and future climate risks.

Coping strategies are defined as a temporary response to a particular condition (Elasha et al., 2005). In this study, coping strategies are the short-term strategies that smallholder farmers adopt to respond to climate hazards.

Livelihood refers to the abilities, assets, and practices to make a living (Serrat, 2017)

ACRONYMS AND ABBREVIATIONS

BGCMA	Breede-Gouritz Catchment Management Agency
FAO	Food and Agriculture Organisation
FGD	Focus Group Discussion
WCG	Western Cape Government
IPCC	Intergovernmental Panel on Climate Change
ODM	Overberg District Municipality
SLF	Sustainable Livelihood Framework
UN	United Nations
WCDA	Western Cape Department of Agriculture
WRC	Water Research Commission
DAFF	Department of Agriculture, Forestry and Fisheries

CHAPTER ONE: INTRODUCTION AND BACKGROUND

1.1 Introduction and background to the study

This thesis was part of the Water Research Commission (WRC) project No. 2022/2023-00845. While other studies in the project looked at water governance and infrastructure, this thesis focused on the impacts of climate change and drought on water availability and the resultant effect on smallholder farm productivity. According to the Intergovernmental Panel on Climate Change (IPCC, 2021), climate change means a change in climate properties for a longer period, such as a decade or more. IPCC (2021) states that climate change is already being experienced in most regions globally, including Africa.

Water resources are crucial for increasing agricultural productivity, but remain a concern under climate change, especially in Africa, where water security is a challenge (Gan et al., 2016). Climate change is expected to increase water scarcity in Africa (Leal Filho et al., 2022; Nhemachena et al., 2020; Schilling et al., 2020; Hamududu & Ngoma, 2020), with dry regions including South Africa, are consistently identified as facing greater risk (Shayanmehr et al., 2022; Faramarzi et al., 2013).

Recent studies show that climate change in Africa is associated with increased warming, variability in rainfall, and regular climate disasters, which include extensive drought and floods (Banerjee et al., 2024; Trisos et al., 2022; Nhemachena et al., 2020). Extremely hot temperatures enhance surface evaporation, reducing water availability (Nhamo et al., 2019) while increasing water demand for crop irrigation (Arfasa et al., 2024; Mostafa et al., 2021). Changes in the frequency and distribution of rainfall due to climate change alter water availability and food production (Banerjee et al., 2024), especially in smallholdings where irrigation water is scarce. These changes may influence the performance of agriculture in smallholdings because the timing and distribution of rainfall determine planting times and the amount of land that can be cultivated.

Although Africa is considered vulnerable to climate change, more impacts on water resources are expected in the southern part of the region (Trisos et al., 2022; Kusangaya et al., 2014). Annual precipitation is estimated to decrease by 20% by the year 2080 (Conway et al., 2015), while the likelihood of long droughts that could last

up to four months increases (Trisos et al., 2022). According to Mafongoya et al. (2022), climate change in southern Africa appears as increased warming, a decline in precipitation, and exposure to climate events. These changes will reduce water availability (Hamududu & Ngoma, 2020) and agricultural productivity by 15% to 50% in the region (Nhemachena et al., 2020), considering that most crop cultivation in southern Africa depends on rainfall for irrigation (Nhamo et al., 2019).

Drought is a natural climatic event that is typical in South Africa (Ruwanza et al., 2022). Drought affects agricultural production, especially in smallholder farming systems, mainly owing to water shortage. There are different types of droughts. The first one is meteorological drought, which represents a period of rainfall scarcity, and when the drought conditions persist, it leads to soil moisture deficit and causes damage to crop known as agricultural drought (Botai et al., 2017). Drought also causes rivers and dams to be dry, known as hydrological drought, and when it starts affecting water access for social and economic use is called socioeconomic drought (Botai et al., 2017). This study focused on meteorological drought as a primary driver of agricultural water shortage in smallholder farming.

Agriculture activities in the Overberg District Municipality (ODM) are vulnerable to climate change due to risks of water shortage (Western Cape Government, 2017). This vulnerability is increased by low adaptation capacity (Western Cape Government, 2017). He & Ding (2023) highlighted that climate change will enhance drought frequencies, including in the Overberg district. This raises concerns for agricultural production, especially in smallholder farming where irrigation water is limited. Many studies in South Africa (Olabanji et al., 2021; Maluleke et al., 2020; Phophi et al., 2020; Rankoana, 2020) confirmed the impacts of climate change and drought on smallholder agriculture. However, a few studies that focused on the Western Cape and Overberg district rarely looked at the impact of climate change and drought on farm productivity; instead, they focused mainly on coping and adaptation methods of farmers (Pili & Ncube, 2022; Fanadzo, Ncube, & Belete; 2021).

Smallholder farmers in South Africa are different in terms of resource access and institutional arrangements, especially in the Western Cape (Fanadzo et al, 2021). Therefore, there is a need for studies focusing on the challenges of smallholder farmers in different settings. Shukla et al. (2019) confirmed that climate change

impacts smallholder farmers differently because of their unique access to resources. Resulting in different experiences in the handling and management of climate shocks and hazards (Fernández et al., 2019). This study argued that the impacts of climate change and drought on agricultural water and effects on farm productivity in smallholder farming in the Overberg district are not well-understood due to limited studies. Therefore, there was a need for an investigation to provide specific data that could be used to inform future climate adaptation in smallholder agriculture.

1.2 Problem statement

The literature suggests that climate change in South Africa appears as an increase in warming, variability in rainfall, and increased risks of repeated drought, which has led to a decline in water availability and agricultural production (Okolie et al., 2023; Rankoana, 2022; Louis & Mathew, 2020; Popoola et al., 2018). The possibility of an increase in drought frequency due to a warmer climate raises concerns about the productivity of smallholder farmers. According to Botai et al. (2017), drought in the Western Cape seems to be part of a normal climate condition. The occurrence of drought is reported to affect agricultural activities in smallholder farming, mainly because of water shortage (Ncube, 2020). Several studies reported that water shortage is one of the major factors constraining agricultural production in smallholder farming (Novienyo et al., 2023; Mwale et al., 2021; Ncube, 2018). Usually, smallholder farmers in South Africa struggle with access to irrigation (Ncube, 2020; Sadiki & Ncube, 2020). The major worry is that a predicted warmer climate is likely to worsen the crisis by depleting the seasonal rivers and small dams that smallholder farmers depend on (Louis & Mathew, 2020; Maluleke et al., 2020; Popoola et al., 2018). These challenges are deepened by weak adaptations and inefficiencies in government policy interventions (Carelsen et al., 2023).

Okolie (2023) noted that smallholder farmers are at risk of losing their means of subsistence owing to a decrease in water resource availability induced by climate change. According to the World Bank (2021), a decrease in water availability will go beyond crop yield reduction to changing land suitability for cultivation due to a lack of adequate soil moisture. Smallholder farming in South Africa contributes to achieving Sustainable Development Goals number one (no poverty) and two (zero hunger) by creating employment, providing income, and increasing household food security (Pili

& Ncube, 2022; Carelsen et al., 2021). However, climate disasters may deter smallholders' efforts to contribute to economic growth and food production, especially in rural areas. The study sought to explore the impact of climate change and drought on water availability and the resultant effect on the productivity of smallholder farmers to provide specific information for future adaptation strategies. As global warming intensifies, the Western Cape will become hotter and drier with increased risk of extreme drought, which could emulate the past water crises that led to water restrictions, including for agriculture (He & Ding, 2023).

Past studies in the Western Cape and Overberg District found that most smallholder farmers lack the necessary resources to deal with current and future incidents of climate disasters (Dippenaar et al., 2022; Pili & Ncube, 2022; Fanadzo et al., 2021; Ncube, 2020). However, these studies mostly focused on the response of smallholders to drought and rarely looked at the impacts of climate change and drought on water availability and the overall effects on smallholder farm productivity. This study sought to bridge the literature void by exploring the impacts of climate change and drought on smallholder farm productivity to inform future adaptations.

1.3 Delineation of the study

The study focused on smallholder farmers in the Overberg District municipality. These were farmers who practised crops and livestock farming in small plots of usually less than a hectare. There is no universal definition of who the smallholder farmers are. While there has been a growing interest in studies focusing on smallholder farming, the definition differs based on geographical settings (Ncube, 2020). The Department of Agriculture, Forestry, and Fisheries (DAFF) in South Africa defines a smallholder farmer as:

“A farmer who produces for household consumption and markets, therefore, farming is consciously undertaken to derive a source of income. These are the 12 new entrants into the mainstream agriculture, aspiring to produce for the market at a profit. Smallholders may have the potential to expand their farming operations and to become commercial farmers (DAFF, 2015:12-13).”

This study used the definition provided by the South African Department of Agriculture, Forestry, and Fisheries to identify smallholder farmers in the Overberg District. The smallholder farmers in the study included communal, subsistence, and emerging farmers because they all practice small-scale farming and have limited access to different capital assets.

1.4 Justification for the study

Smallholder farming in South Africa creates employment and contributes to food security. Literature as reviewed by Zwane (2019) indicated that climate change in the Western Cape reduced water availability, resulting in a decline in agricultural productivity. Despite this, fewer studies focused on the effects of climate change and drought on agricultural water availability and effects on-farm production to inform future adaptation strategies. This thesis sought to provide insights to guide policies and programmes aimed at supporting smallholder farmers.

1.5 Research questions

The following questions guided the study:

- How do water resource availability and access influence smallholder farm productivity?
- What are the socioeconomic impacts of climate change and drought on smallholder farmers?
- How do smallholder farmers cope and adapt to the impacts of climate change and drought?

1.6 Aim and objectives of the study.

The study aimed to explore climate change and drought impacts on agricultural water availability and resultant effects on smallholder agricultural productivity. The following objectives guided the study:

- Explore the impacts of climate change and drought on agricultural water availability and access in smallholder farming in the Overberg District, Western Cape.

- Investigate the effect of climate change and drought on smallholder agricultural productivity and its impact on the livelihood and well-being of smallholder farmers in the Overberg District, Western Cape.
- Identify and analyse the strategies implemented by smallholder farmers to minimise the effects of climate change and drought on farm productivity.

1.7 Structure of the dissertation

The thesis consisted of five chapters:

Chapter One presented the study introduction and background. Followed by a presentation of the research problem, the motivation for the study, and the research questions and objectives that guided the study.

Chapter Two provided a discussion of the literature review with a focus on the impacts of climate change and drought on the productivity of smallholder farmers. The chapter also covers a discussion on the concepts of smallholder farming, sustainable livelihood, vulnerability, coping mechanisms, and adaptation measures.

Chapter Three presented an overview of the research methodology that was employed to achieve the research objectives. This chapter outlined the research design, methodological approach, data collection instruments, sampling procedure, data analysis techniques, and ethical considerations of the study.

Chapter Four presented and discussed the findings to answer the research objectives in comparison with previous studies to identify similarities and contradictions.

Chapter Five is the conclusion and recommendations of the study.

1.8 Chapter conclusion

Climate change threatens the existence of smallholder farming systems, which are crucial for poverty alleviation and development in rural areas. One cannot disagree that commercial farmers are not spared from the consequences of climate change, but the smallholders show greater vulnerability because they have limited support and practice low-input farming. This chapter provided the reader with information about the

study context, problem statement, delineation, and justification of the study. They were followed by the research questions, objectives, and structure of the dissertation. The following chapter focuses on the literature review.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter focuses on the impacts of climate change on agricultural productivity, livelihoods, well-being, and the understanding of coping and adaptation mechanisms among smallholder farmers. The chapter starts by presenting an overview definition of the term 'smallholder farmers' with emphasis on the South African context. This is followed by presenting and discussing the sustainable livelihood approach (SLA) as the conceptual model guiding the formulation and design of this study. Therefore, it highlights the advantages and disadvantages of the SLA.

The literature presents the effects of climate change on smallholder farmers from an international perspective, including in South Africa. The responses and challenges that smallholder farmers face when trying to cope and adapt to the effects of climate change are highlighted.

2.2 Defining smallholder farming

Smallholder farming plays a crucial role in sustaining food production in developing countries as a leading economic activity for most rural communities (Tindiweni et al., 2021). The Food and Agriculture Organisation (FAO, 2013) reports that smallholder farmers in Asia and sub-Saharan Africa contribute to over 80% of the food supplies and manage most of the farmland. Each farmer can manage a piece of land ranging from less than a hectare to 10 hectares (FAO, 2013). Smallholder farming is generally characterised as small-scale farming that usually relies on family labour, and the motives for farming are predominantly for household use and selling the surplus to generate income (FAO, 2013). A smallholder farmer is an individual who is engaged in a small operation of either crop, livestock, or mixed farming (Ruwanza et al., 2022).

The definition and method of classifying smallholder farmers remain ambiguous. Ncube (2020) highlights that the meaning of a smallholder farmer can be context-based. As a result, different societies may have different understandings of who a smallholder farmer is. The ambiguity in defining a smallholder farmer creates challenges for proper classification and determination of the level of support required by this group of farmers. Smallholder farmers are not uniform but rather a diverse

group of people with different resource needs and farming styles (Carelsen et al., 2021). This also makes defining smallholder farmers very complex. Ncube (2020:5) defines smallholder farmers as “farmers with inadequate resource endowment relative to other farmers in the sector”. Ruwanza et al. (2022) describe smallholder farmers as individuals who practise crop or livestock farming on a small piece of land. The term ‘smallholder farmers’ is an umbrella term for different groups of farmers practising in small plots. It includes those who practise in the backyard, subsistence farmers, and communal farmers.

The most common feature that distinguishes smallholder farmers from other groups of farmers is land size and ownership (Tindiwensi et al., 2021; Ncube, 2020; FAO, 2013). Smallholder farmers are differentiated by owning and farming small pieces of land. However, Kirsten and van Zyl (1998) claimed that land size as a measure of classifying smallholder farmers is not adequate because a farmer practising on small but high-quality land may yield more profit than someone who owns a bigger farm which is of low quality. Kirsten and van Zyl (1998) stated that a farmer who owns bigger land but produces less is fit to be classified as a small-scale farmer. However, this does not take away the fact that smallholder farmers have restricted access to land (Ncube, 2020). As a result, they are unable to expand their operations. The land size determines the productivity and growth of smallholder farmers. Access to adequate arable land is essential for the development of smallholding into commercial farming. Kirsten and van Zyl (1998) proposed a two-variable criterion for classifying smallholder farmers, which states that they are farmers with a very small operation and production.

According to Thamaga-Chitja & Morojele (2014), smallholders are separated from other farmers in the sector by resource ownership and farm production. They are typically located far from urban areas with poor service delivery and are also limited in market participation (Tindiwensi et al., 2021). Smallholder farmers in South Africa are predominantly disadvantaged and have limited educational opportunities (Thamaga-Chitja & Morojele, 2014). They are usually located in rural areas where there is high unemployment and poverty, including limited access to social services and critical infrastructures like proper roads (Matlou et al., 2021). It is estimated that two million smallholder farmers in South Africa contribute to food and nutrition, mostly in rural areas (WWF, n.d.). The General Household Survey (Stats SA, 2022) reports that more

than three million households are engaged in farming activities. About 86% of the households were farming mainly for consumption, and only 9% were farming to generate income. Even though the number of smallholder farmers is remarkably high, large-scale commercial farmers remain the biggest contributors to agricultural outputs from a national outlook (Mathinya et al., 2022). Nonetheless, the impact of smallholder farming on sustaining local food supplies cannot be downplayed (Ruwanza et al., 2022). Mathinya et al. (2022) conclude that the understanding of smallholder farming systems in South Africa is limited. Furthermore, Mathinya et al. (2022) argue that the restrictions and prospects of the development of smallholder farming are not well understood (Mathinya et al., 2022). They posit that climate change is among the challenges hindering the growth of small-scale farmers.

2.3 Conceptual framework

This study was designed and formulated using a sustainable livelihood approach (SLA) model introduced by the Department for International Development (DFID), dating back to the early 1990s. A livelihood can simply be defined as a way in which people earn a living. It consists of skills, resources, and activities required to earn a living (DFID, 1999). Smallholder farmers have different skills, resources, and off-farm strategies that they combine to make a living (Fanadzo et al., 2021). It is important for smallholder farmers to achieve a sustainable livelihood to ensure long-term security of income, food availability, and access. A livelihood can be considered sustainable if it can adjust to stress while maintaining its capacity without causing an impact on the natural environment (DFID, 1999).

The justification for adopting the SLA in this study is that it provides it takes a holistic view in assessing the livelihoods of the poor or underprivileged (Serrat, 2017). Therefore, it provides a framework that helps determine critical areas that require intervention for development and alleviating poverty through the lens of the beneficiaries (Serrat, 2017; Krantz, 2001). This approach integrates a sustainable livelihood framework (SLF) as a tool for analysing and understanding livelihoods (Figure 2.1). The SLF consists of five integrated elements, namely the (1) vulnerability context; (2) livelihood assets; (3) policy and institutions; (4) livelihood strategies; and (5) livelihood outcomes.

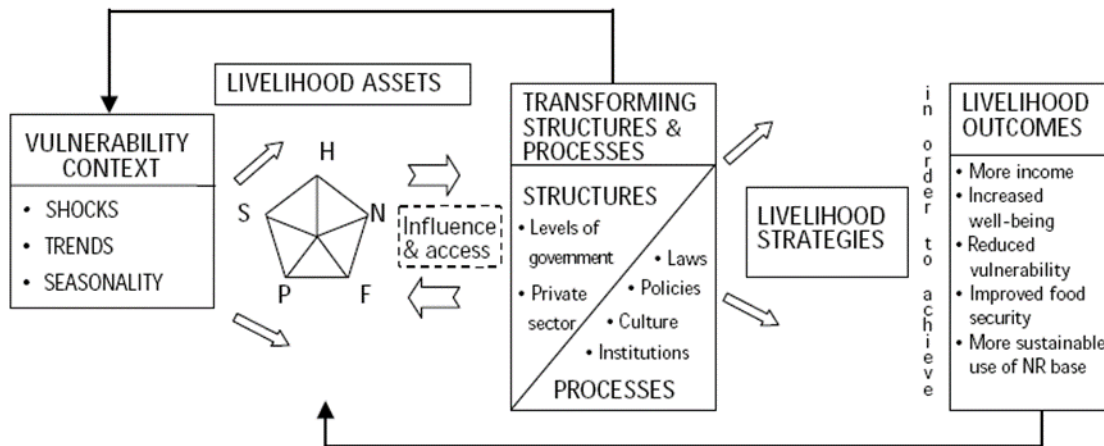


Figure 2.1: Sustainable livelihoods framework (DFID, 1999)

The SLF is among the popular frameworks used for assessing the livelihood vulnerabilities to extreme weather events in rural communities. For example, Ncube et al. (2018) used the SLF as model to analyse the vulnerability of women to drought in rural areas. Pandey et al. (2017) adopted the SLF to analyse the adaptation mechanism and vulnerability of household’s farmers to climate hazards in the Himalayas region. Likewise, Mabuku et al. (2019) used the SLF to investigate the adaptation strategies adopted by villagers in Namibia and Zambia to reduce the impacts of floods on their livelihoods. Other scholars such as Fanadzo et al. (2021) deployed the SLF to analyse the livelihoods of smallholder farmers and their adaptation strategies to drought. In this study, SLF was deployed to analyse the strategies adopted by smallholder farmers to respond to extreme weather conditions in the Overberg District.

The SLF suggests that people may be vulnerable to internal and external changes and may have access to different resources governed by policies, processes, and institutions. The dynamics between these two determine their livelihood strategies and outcomes (Tham-Agyekum, 2015; Jethwani & Mishra, 2012). The next sections briefly discuss the five components of SLF.

2.3.1 Vulnerability context

Vulnerability simply refers to the level of exposure to hazards (GLOPP, 2008). Serrat (2017) contends that vulnerability has two elements – the external, which includes seasonal change, trends or shocks, and the inner side, which comprises the inability to deal with uncertainty. Vulnerability context includes several factors that can be grouped into three categories: shocks, critical trends, and seasonality (GLOPP, 2008). Shocks refer to unprecedented events such as natural disasters, conflicts, pests, and/or diseases, while seasonal change may represent fluctuations in prices and employment, including impacts on the availability of resources such as food. Major trends could represent a change in demographics, government policy, markets, and technological advancement (Serrat, 2017). The vulnerability context limits the strategies that people embark on to meet their needs (Serrat, 2017). Generally, people have little or no control over external factors (Tham-Agyekum, 2015). Hence, communities must strengthen their adaptive capacity against future stressors. However, not all of these factors are associated only with negative impacts. Seasonality and critical trends can be positive for people’s livelihood, in some instances (GLOPP, 2008).

2.3.2 Livelihood assets

Different communities rely on tangible and non-tangible resources to build their livelihoods. These resources are classified into different livelihood capitals, which are human, social, natural, physical, and financial resources (Fanadzo et al., 2021; Serrat, 2017; Krantz, 2001). Human capital includes “health, education, knowledge, and skills.” (Jethwani & Mishra, 2012). The social capital includes: 1) networks and interconnections that enhance people’s confidence and capabilities to work as a group for mutual benefits and to increase their access to institutions with broader objectives; 2) participation in formal social structures that are governed by certain rules, norms, values, and sanctions; and 3) mutual relationships and trade-offs that accelerate partnerships, reduce the costs of selling and buying, and provide security among poor people (UNDP, 2017).

Smallholder farmers also rely on natural resources to support their livelihoods. These resources may include land, trees, and water production, as well as intangible assets

like climate and biodiversity. For small-scale farmers, who practise low-input agriculture, natural assets are key to their farm productivity, such as rainfall for crop irrigation and trees for climate adaptation (Shikwambana et al., 2021).

Physical capital consists of basic infrastructure for services and tools for improving productivity, both critical for sustainable livelihoods (Fanadzo et al., 2021). It influences access to basic services, such as shelter, information, safety, affordable transport, water, sanitation, and energy. Last, financial capital includes access to savings, wages, credits, and remittances (Serrat, 2017). Financial capital plays a crucial role in enabling individuals to invest in different opportunities and manage their financial affairs.

Access to resources is also governed by policies and institutions. These institutions can be formal or informal, directly or indirectly facilitating access to capital assets (Serrat, 2017). Subsequently, it affects how people make a living. In addition, the sustainability of the livelihood outcome is determined by policies and institutions (Massoud et al., 2016) because they facilitate access to capital assets. However, the policies and institutions are continuously changing and are ambiguous (Krantz, 2001).

Livelihood encompasses activities that people undertake to make a living (GLOPP, 2008). Therefore, the livelihood strategies consist of choices and activities that individuals combine to fulfil their daily needs. This could include on-farm and off-farm activities that people undertake to earn an income. Livelihood strategies are directly affected by policies and institutions (Tham-Agyekum, 2015). They determine access to social, financial, human, natural, and physical assets needed for people to sustain their livelihoods

The outputs of the activities and choices (livelihood strategies) that people undertake to earn a living are referred to as livelihood outcomes. It can include reasonable utilisation of natural resources, good health, income improvements, enhanced resilience, improved food stability, and standard of living (DFID, 1999).

2.4 Benefits and limitations of a sustainable livelihood framework

The SLF has been widely used as an instrument for project planning and poverty reduction in communities (Krantz, 2001). SLF provides a comprehensive overview of different livelihood activities in which people participate to maintain their livelihoods (Muringai et al., 2020). It is assumed that economically disadvantaged people usually depend on more than one livelihood strategy, which greatly influences their income (Krantz, 2001). Therefore, approaches that focus on an exclusive industry are likely to fall short of addressing all the elements that influence the livelihood of the marginalised individuals (Tham-Agyekum, 2015). This means sector-specific approaches may pay attention to certain elements of the livelihood strategies that may not be important or even relevant to the needs of the intended beneficiaries (Krantz, 20001). Therefore, SLF acknowledges the importance of the interconnection between sectors (Serrat, 2017). Hence, SLF emphasises the importance of linking local livelihood strategies with national or provisional government institutions and policies, including connecting formal institutions with informal networks.

The SLF provides a comprehensive model for assessing the livelihood capitals that people have access to and the way they impact their livelihoods (DFID, 1998). The SLF helps determine the factors that constrain people from accessing certain resources and the impact they have on their livelihood strategies and livelihood outcomes. This is key to understanding the underlying causes of poverty.

Another advantage of using the SLF is that it provides a tool for understanding how people adjust and respond to shocks and hazards (Fanadzo et al., 2021). Thus, the SLF focuses more on people's abilities rather than their needs and problems (GLOPP, 2008). This simply means SLA focuses on building community resilience against shocks rather than just fulfilling their needs, such as providing relief to shocks and hazards.

Moreover, the SLF embraces a people-centred principle. It places people at the centre of development by involving the community in planning and making decisions about their future. Therefore, project beneficiaries may have the opportunity to determine their goals and shape the development to reflect their needs. The SLF is dynamic and flexible (Kollmair & Gamper, 2002). It can help project managers to analyse and learn

from changes that happen in people's livelihood strategies and at the institutional levels to minimise negative impacts and ensure positive change (GLOPP, 2008). SLF can be used to identify community priorities before projects are implemented and for monitoring and evaluation.

Notwithstanding the benefits, SLF also faces criticism for failing to identify the "poor", despite its claims regarding poverty reduction. Poverty is not limited to economic exclusion, but also includes deprivation of healthcare and social services, which do not spread equally throughout the community (Krantz, 2001). The multiplicity of standards of poverty ranking also poses a practical challenge in identifying the poor, and the SLA is not clear on this question (Krantz, 2001).

Despite the SLA claiming to be people-centred, the people remain invisible, and it pays little attention to power dynamics (Serrati 2017). Moreover, the SLA is accused of downplaying other factors that trigger livelihood vulnerability, for instance, conflicts and changes in economic behaviours at the household or local level (Serrat, 2017). It is also perceived that enhancing the livelihood of one group could weaken the livelihood of others (GLOPP, 2008).

Natarajan et al. (2022) criticise the SLA for ignoring past events that shape present-day livelihood and only focusing on current situations. This includes overlooking historical issues, either at a larger scale, such as colonialism, or short-term changes, which could consist of a change in policy and/or local problems, such as land dispossession. Natarajan et al. (2022), emphasise that it is important to understand livelihoods not only in their current form but also to consider the historical context and institutional processes that have influenced them. Accordingly, in South Africa, ownership of land and access to water for agriculture are influenced by past policies and the injustices of racial segregation (Ncube, 2020).

Methodologically, the SLA is criticised for failing to analyse and acknowledge gender dynamics concerning labour in the household and its impact on livelihood outcomes (Natarajan et al., 2022). Krantz (2001) highlights that the problem of SLA is that it focuses on analysing the household as a unit with little emphasis on gender. Therefore, women risk not being classified as poor if they are not the leaders of the households, even if such individuals are economically and socially marginalised. The

SLA is accused of being too ambitious and practically unrealistic for suggesting a broad and open-minded approach to analyse factors that affect people's livelihoods (Krantz, 2001). This wider approach may also result in the gathering of larger amounts of information that could be difficult to manage (GLOPP, 2008).

2.5 International literature on the impacts of climate change on smallholder agriculture

In the African continent and Asia, smallholder farmers significantly improve food availability at the household level (FAO, 2013). However, they are susceptible to extreme weather conditions (Shikwambane et al., 2021). For instance, in Iran, Jamshidi et al. (2019) assessed the risks of climate change to smallholder farming in the Hamadan region. Their study found that most farmers were susceptible to climate hazards. The same study revealed that farmers experienced drought, which led to water shortages. Frequent drought episodes hurt the farming productivity of smallholdings because of reduced agricultural water availability and access.

Smallholder farmers continue to be exposed to and highly impacted by the harsh conditions of a changing climate. Omerkhil et al. (2020) investigated the climate change risks and response strategies of smallholder farmers in Afghanistan. Their study found that 51% of participants were vulnerable to climate change, and 42% showed low adaptation. The same study highlighted that smallholder farmers require financial support for climate resilience. Smallholder farmers have poor access to various capital assets, which makes them more vulnerable to shocks and disasters.

Pickson & He (2021) report that smallholder farmers in China experienced a shortage of human resources to support the labour demands on the farms. As a result, the smallholder farmers were limited in adapting to climate change despite being aware of the repercussions on farm productivity, also because of water shortage, inadequate land sizes, and limited access to climate information (Pickson & He, 2021). Smallholder farmers require access to various capital resources for them to adapt to climate change and farm effectively.

Shrestha et al. (2022) found that climate change exposed smallholder farmers to multiple disasters, such as drought and floods, which negatively impacted crop yields

and household income. While the study reported some contradictions and consistencies in farmers' perceptions when compared with climate data, the authors concluded that understanding farmers' experiences of climate change is crucial for providing data to inform future adaptation.

Dahal et al. (2023) confirmed that climate change affects the livelihood of smallholder farmers due to its negative impacts on farm production. Farming is a vital source of sustenance for smallholder farmers. Therefore, any disturbance to their crop yields will negatively impact on their livelihood and wellbeing. The major impact of climate change on crop production in smallholder farming is a rainfall deficit (Shah et al., 2023). This is because smallholder farmers are limited in access to irrigation water and rely heavily on rainfall for crop production. Water shortage in smallholder agriculture not only results in slow crop production but also hinders the efforts to climate adaptation, even in Bangladesh (Mamun et al., 2021). However, Shukla et al. (2019), in India, confirmed that the impact of extreme weather conditions is not experienced the same among smallholder farmers. Smallholder farmers are not uniform but rather a diverse group with different access to resources and support. Therefore, the impacts of climatic hazards on the productivity and well-being of smallholder farmers are not uniform.

The assessment of the effects of changing climate on the productivity of smallholder farmers based on their level of access to resources requires further investigation. Most studies have used a blanket approach when evaluating the risks of a changing climate in smallholder agriculture. There is a need for understanding the individual circumstances of smallholders to inform future adaptation strategies. Zeleke et al. (2021) confirmed that economically disadvantaged smallholder farmers in Ethiopia were more prone to harm by climate hazards and shocks.

Mumo et al. (2018) claim that climate change in sub-Saharan countries will cause a decline in maize production owing to predicted warm temperatures and low precipitation. Maize farming in developing countries is mostly rainfed (Oseni & Masarirambi, 2011). A decline in annual precipitation and a temperature rise will harm maize production. Maize is a staple food in most African countries. Rural household farmers usually cultivate maize seasonally to improve their access to staple food. Therefore, a decrease in maize production may trigger food insecurities at the

household level, especially for farmers who rely on agriculture as the main economic activity.

Antwi-Agyei & Nyantakyi-Frimpong (2021) highlighted that smallholder farmers in Ghana experienced inconsistent precipitation, an increase in strong winds, floods, as well as hot extremes, and hydrological drought, owing to a changing climate. Such climate hazards constrain the productivity of smallholder farmers. For example, Mbuli et al. (2021) assessed the susceptibility of smallholder farmers to climate hazards and impacts on their livelihood in Cameroon. Mbuli et al. (2021) discovered that a change in climate intensified the challenges of smallholder farmers, triggering food insecurity challenges. The same study concluded that the lack of strategies to adapt to shocks and hazards such as droughts and floods caused a decrease in crop production (Mbuli et al., 2021). The risks of climate change to smallholder farming are exacerbated by low adaptive capacity. Conversely, Derbile et al. (2022) found that smallholder farmers in Ghana were highly exposed to risks of human activities rather than climate disasters. However, Derbile et al. (2022) confirmed that exposure to climate disasters could intensify the food security challenge for smallholder farmers. Cudjoe et al. (2021) confirmed a decline in maize production among smallholder farmers in Ghana due to rainfall scarcity and frequent drought. Bako et al. (2022) report that smallholder farmers in Nigeria experience low crop production due to extreme weather conditions and a lack of adaptation. Building capacity for adaptation to increase food production in smallholder farming has been suggested (Mekonnen et al., 2021).

Abdisa et al. (2022) assessed the effect of temperature and precipitation changes on rainfall-dependent, small-scale farming in Ethiopia. Their study concluded that maize and sorghum production was influenced positively by minimum temperatures and rainfall, while increased temperature correlated with a reduction in crop yields. This was consistent with recent projections that a continuous increase in global temperature will cause the agricultural sector many losses.

Mafongoya et al. (2022) state that climate change in southern Africa is characterised by exposure to droughts and heat waves, reducing food production, limiting access to food, and threatening food stability. Ngoma et al. (2021) predict that climate change will reduce rainfall by up to 5% and increase temperature by 1.8 °C by 2050 in the south and western parts of Zambia. As a result, crop yield and production will decline,

especially in rainfed maize farming, subsequently causing a decrease in agricultural economic activities and impacts on household socioeconomic standing. Moreover, Mafongoya et al. (2022) state that climate change also affects food utilisation because it introduces pests and diseases that cause crop damage. Skendžić et al. (2021) confirmed that climate change influences changes in agricultural pest populations, including increased pest distribution, reproduction, and resistance to environmental or chemical control. This will be a challenge for smallholder farmers to manage, considering that they have limited resources.

Amani et al. (2022) explored the effect of a changing climate on smallholders in the eastern Congo, on their farming activities. Their study found that smallholder farmers perceived increased temperatures, severe drought, and low and late precipitation as the main changes experienced. The same study found that the farmers experienced low crop yields and an increase in crop, animal, and human diseases, such as malaria, due to changes in climate conditions. Adverse climatic conditions are hampering the productivity of smallholder farmers. Etongo et al. (2022) reported that smallholder farmers in Seychelles experienced a decline in crop yields due to an increase in climate hazards. Tiyo et al. (2015) provided evidence that smallholder farmers are aware of climate change impacts on their livelihood. Despite the knowledge, they remain at risk to these climate extremes (Makuvaro et al., 2018). Hence, it is recommended that government institutions should provide support to smallholder farmers to reduce their vulnerability (Twecan et al., 2022). Nonetheless, the effects of climate change are not unique to Africa and Asia. Similar trends of climatic hazards that threaten productivity in smallholder agriculture were observed in the central, northern, and southern parts of America. Donatti et al. (2019) examined the susceptibility of smallholder agriculture to a changing climate in Central America and Mexico. Their study found a gap in the literature focusing on the vulnerability of agricultural production to climate change in smallholdings. Donatti et al. (2019) contend that the gap in information concerning the climate vulnerability of smallholder agriculture may hinder the development of programmes to assist smallholders adapt to climate extremes.

In Chile, Fernández et al. (2019) confirmed that smallholder farmers were at risk of water scarcity due to a warmer climate. Fernández et al. (2019) predicted that poverty-

stricken households will experience high losses in farm income. Inequalities in resource access among smallholder farmers should be considered in a vulnerability risk assessment. For example, Fernández et al. (2019) observed that smallholder farmers from households with more members adapted better to the effects of a changing climate by engaging in non-farming activities to yield an income. In Central America, Harvey et al. (2018) found that about 30% were food insecure and over 40% experienced a loss of income due to climate change. The same study established that farmers responded to the effects of extreme weather by planting trees to mitigate the effects of climate change.

Landaverde et al. (2022) Investigated climate perceptions of smallholder farmers in Peru. Their findings highlighted that most farmers perceived climate change to have caused a variability in rainfall, increased warming, and a series of droughts. In addition, farmers perceived climate change to have a bearing on crop yields and household income. Landaverde et al. (2022) concluded that perceived impacts of climate change by farmers informed the type of adaptation methods. Although most studies have demonstrated that climate change threatens the productivity of smallholder agriculture, there is still a gap in studies that quantify the losses on crops, livestock, and income.

2.6 A review of climate change and drought impacts on smallholder farmers in South Africa

2.6.1 Impact on water resources

Climate change affects water resource availability and access for smallholder farmers through rainfall scarcity and extremely hot temperatures, leading to severe and prolonged drought. Shikwambana et al. (2021) highlighted that this variability in rainfall and temperature influences water resources. Olabanji et al. (2020) showed that climate change affects water security negatively in the Olifants catchment because of a decline in rainfall and an increase in temperature, aggravated by an increase in water demand. Excessive warm temperatures, combined with a decline in average rainfall, induce drought episodes (Shikwambana et al., 2021). Drought is part of regular climate conditions in South Africa, which causes water shortage in smallholder agriculture

(Ncube, 2020). It restricts smallholder farmers from accessing agricultural water for domestic leading them to abandon their farming activities (Louis & Mathew, 2020).

The influence of a changing climate on water resources in smallholder farming may be felt through a decline in rainfall and loss of water sources. For example, a study by Rankoana (2020) found that water boreholes and seasonal rivers were suppressed owing to increased warming and low rainfall in the Limpopo province. Smallholder farmers mostly rely on rainfall for crop irrigation (Rankoana, 2022). Thus, climate change restricts smallholder farmers from accessing water for agriculture because it is associated with dryness. Popoola et al. (2018) learned that extreme weather conditions, in particular, increased warming and precipitation decline, dried up local water sources, and constrained the farm productivity of smallholding agriculture in the Eastern Cape. Okolie et al. (2023) highlighted that climate change harmed water resources in the Thaba Nchu, Free State area, and more than 50% of smallholders who were interviewed reported that they stopped farming owing to water scarcity caused by drought. Therefore, the impacts on water resources adversely affect the actions and choices of smallholder farmers trying to earn a living.

2.6.2 Impacts on crop production

Most smallholder farmers in South Africa are engaged in rainfed agriculture. Farmers of this type have poor access to physical, natural, and capital assets (Matlou et al., 2021). Consequently, they are susceptible to climate risks – for example, inadequate access to water resources limits smallholder farmers from sustaining their crop production during drought. In another finding by Louis and Mathews (2020), they observed that exposure to climate hazards, such as droughts, constrained crop production in smallholder agriculture. Drought affects crop production mainly due to water shortage (Fouotsa, Manfouo & Von Fintel, 2022).

Elum et al. (2017) reported a decline in crop yields among smallholder farmers who were farming potatoes and cabbage due to heightened temperatures and pests in the Mpumalanga, Limpopo, and Gauteng provinces. Smallholder farmers often struggle to implement proactive strategies, which may be attributed to resource limitations. A study by Ncube et al. (2016) focusing on smallholder farmers in Limpopo and Eastern Cape provinces found that households with fewer capital resources are highly

susceptible to climate change, as crop production is expected to decline in rain-dependent farming systems. As discussed in the previous chapter, climate change in South Africa shows a decline in precipitation and temperature rise. As a result, small farms that rely heavily on rain-irrigated systems are expected to experience a decline in crop yields.

A study by Meza et al. (2021) confirmed that all municipalities in South Africa experienced a series of drought events in the past 30 years, with greater risks of drying being observed in the north, central, and western regions. Similarly, the smallholder farmers in the Overberg district were exposed to drought. Hawkins et al. (2022) confirmed that smallholder farmers in KwaZulu-Natal experienced a loss in crop production. A study by Phophi et al. (2020) highlighted that smallholders who practise vegetable farming in Vhemebe District perceived warmer winters, dry spells, and rises in temperature as indicators of climate change, which cause the outbreak of pests in crops. Poor pest management may lead to crop losses, thus affecting food availability for smallholder farmers.

Rankoana (2022) reported that a decline in annual rainfall and heightened temperatures led to a decrease in crop yield in smallholder farming in Limpopo. Smallholder farmers remain vulnerable to extreme changes in climate patterns. However, a study by Afful & Ayisi (2020) in Limpopo reported that no significant difference was found in crop yields between recipient and non-recipient farm extension officers in Limpopo. They concluded that external assistance offered to smallholder farmers was inadequate to improve crop production during a changing climate. Extension support may help smallholder farmers adapt better to environmental changes.

A study by Ubisi et al. (2017) found that 70% of smallholder farmers who participated in their study perceived climate change to have caused drought in their areas, which resulted in crop failure in Limpopo. Mthembu & Zwane (2017) confirmed that smallholder farmers experienced slow growth in crop production because of drought. Similarly, Zwane (2019) reported that drought adversely affected livestock and crop farming, leading to a huge decline in agricultural production. Popoola et al. (2018) reported that rainfall deficit and temperature extremes, because of climate change, constrained crop production in smallholder farming.

Myeni & Moeletsi (2020) report that climate change reduced crop production, resulting in increased cost of food and declining access to food. The impacts of extreme weather conditions on smallholder farmers' crop production are apparent. However, it is unclear from previous studies how much crops smallholder farmers are losing owing to harsh weather patterns. Most studies did not look deeply into the losses of smallholder farmers on crops, livestock, and income. There is a need to understand the losses accumulated by smallholders because of climate change to inform future adaptation strategies.

2.6.3 Impacts on livestock

The impacts of adverse changes in climatic conditions on livestock productivity are widely reported. Maluleke et al. (2020) concluded that progress in rural livestock farming has been significantly reversed by the effects of climate change and termed it a “win or lose business”, which is not profitable anymore. Maluleke et al. (2020) suggest that smallholder farmers can now only keep a few livestock because they lack the necessary means to deal with the effects of climate change, like buying fodder or finding alternative water resources during drought. This may have negative consequences on agricultural development in rural areas. Agriculture is usually the primary means of income generation and food production for people in rural areas. Therefore, regression in rural livestock farming may leave several households with little or no income and may impact food security.

Maluleke and Mokwena (2017) learned that smallholders in Giyani experienced a loss through livestock mortality owing to disease outbreaks and undernourishment related to extreme weather conditions, in particular, temperature increase and dryness, leading to the deterioration of the veld. Likewise, Nesamvuni et al. (2022) observed that smallholders in the Limpopo and Mpumalanga provinces witnessed a decline in communal land grasses owing to adverse climatic conditions. The same study highlighted that farmers in the two provinces viewed the reduction in grazing capacities as having caused livestock fatalities. Nesamvuni et al. (2022) established that the smallholders lacked systems for early detection of climate change risks. In addition, they also lacked strategies in place to deal with future events of harsh climatic conditions like drought. This means that, under similar circumstances of climate change and drought, there is a possibility that smallholder farmers will suffer similar

consequences as they did in the past. Hawkins et al. (2022) assert that extended drought periods can be seen as the effects of a changing climate that affects farm productivity, particularly smallholdings. Considering that climate change is linked with the increase in the frequency of long-term drought, smallholder farmers will most likely experience a loss of livestock.

Vetter, Goodall & Alcock (2020) reported that cattle farmers lost over 40% of their herds and goat farmers lost 29% of their herds during drought. The same study also found that the number of cattle remained affected three years later after the drought had occurred. This suggests that the effects of drought on farmers may last longer and that farmers with poor coping and adaptation strategies may experience long-term effects. Likewise, Mthembu & Zwane (2017) reported that in KwaZulu-Natal, livestock farmers experienced huge mortalities of cattle during drought between the years 2010 and 2014. A study by Rakgwale & Oguttu (2020) reported that farmers in Limpopo experienced a decline in the number of livestock due to the impacts of the 2014 to 2016 drought period. This section has highlighted numerous periods of drought events. Drought has become a frequent natural disaster in South Africa.

Popoola et al. (2019) found that smallholders practising poultry agriculture in the Eastern Cape considered changes in climatic conditions to have a bearing on egg and meat production. The preliminary literature shows that fewer studies have focused on small poultry. There is a gap in studies that focus on small-scale poultry farmers.

2.6.4 Socioeconomic impacts

Climate change exposes smallholder farmers to the risk of losing their means of subsistence. Shisanya & Mafongoya (2016) showed that subsistence farmers in the UMzinyathi District Municipality, KwaZulu-Natal, were worried that they would experience erratic rainfall, drought, and soil erosion owing to changes in climatic conditions. Shisanya & Mafongoya (2016) emphasised that previous experiences of changes in weather conditions made farmers anxious about the possibility of adverse effects on their livelihood. They also reported that farmers were vulnerable to climate change and that most of them were food insecure. Therefore, a shift in weather conditions in the form of hot extremes and rainfall scarcity is likely to exacerbate their challenge to food security, considering that they have low adaptive capabilities.

Likewise, Rankoana (2022) found that smallholder farmers in Limpopo were unable to ensure adequate food production for household consumption due to the unfavourable climate conditions.

Tibesigwa et al. (2015) claim that subsistence farmers are likely to face increased profit losses in the long-term owing to predicted changes in climate conditions. However, the same study suggests that farmers who engage in mixed farming practices are less vulnerable to these changes compared to those who rely solely on crops. Diversified small farming systems are better equipped to handle shocks and to support farmers in adapting to climate change.

Myeni & Moeletsi (2020) report that climate change impacted food security in the Eastern Cape. Climate change is projected to reduce water resources and crop production. Consequently, the income and food access for farmers will be impacted, leading to insecurities. Similar findings were reported in the Kwazulu-Natal province by Hawkins et al. (2022) where the occurrence of drought reduced access to sufficient, high-quality food for farmers. Ubisi et al. (2017) also reported that smallholders resorted to scaling down food consumption and adjusting their diet because of a shortage, and experienced emotional effects. This suggests that the occurrence of extreme weather events will limit smallholder farmers' access to nutritious food.

A study by Okolie et al. (2023) reported a decrease in the level of food consumption at the household by over 30% in the Free State province. The same study also reported that the choice of diet was affected due to drought. Furthermore, the farmers were exposed to mental health effects such as anxiety and depression. Okolie et al. (2023) also found that most of the households that participated in the study experienced water shortages as a result, and some had to give up farming, losing their important source of livelihood. Louis and Mathew (2020) also reported that water shortage led to subsistence farmers abandoning their farming activities in Limpopo.

Fanadzo et al. (2021) reported the social and economic impacts of drought on smallholder farmers: 1) conflicts in water sharing among farmers owing to shortages; 2) distress; and 3) loss of income owing to crop failure and livestock losses. Smallholder farmers are losing crops and livestock, which happen to be their main source of livelihood, from climate disasters. Surely, this is likely to hurt their well-being.

Nkosi et al. (2023) reported a reduction in income over two growing seasons for smallholder farmers who produce maize in Mpumalanga because of a decline in crop yields, which farmers suggested was caused by challenges linked to an unpredictable change in the climate.

Mthembu & Zwane (2017) reported that drought puts pressure on the limited income of smallholder farmers because of high food prices and the costs of farm inputs. A study conducted in the Eastern Cape by Mdoda et al. (2020) reports that variations in temperatures owing to a changing climate impact the earnings of smallholder farmers. Mdoda et al. (2020) learned that only in summer does an increase in temperature of 10 degrees Celsius result in profit loss, but it drives total farm revenue high when it increases in winter, autumn, and spring seasons.

Bahta & Myeki (2022) looked at the burden posed by drought on smallholders practising livestock agriculture in the Northern Cape. In their findings, they discovered that drought affected food stability and access to capital assets. A study conducted in the Northern Cape found that drought relief assistance improved security in smallholding agriculture (Matlou et al., 2021). However, the same study found that there were disparities in farmers' improvement based on their gender, with female farmers showing little progress compared to male farmers. Some studies showed that most male farmers had better adaptation capacity relative to female farmers. Therefore, it is important to consider the social characteristics of an individual farmer when analysing challenges and constraints to prosperity. Table 2.1 below present the social, economic, and environmental challenges of climate change perceived by smallholder farmers in South Africa.

Table 2.1: Impact of climate change identified by smallholder farmers in South Africa

Category	Effects
Social	<ul style="list-style-type: none">• Water scarcity• Food insecurity• Stress• Decrease in food choices
Economic	<ul style="list-style-type: none">• Reduced crop production• Livestock mortality• Loss of income• Increase costs of farm inputs• Abandoning cultivation• Migration• Increased food prices
Environmental	<ul style="list-style-type: none">• Increased temperature• Declining rainfall• Drought• Pest outbreak• Floods• Veld deterioration• Deterioration of water resources

Sources: (Okolie et al., 2023; Maluleke et al., 2020; Popoola et al., 2018; Ubisi et al., 2017; Mokwena & Maluleke., 2017)

2.7 A general review of coping and adaptation strategies

Smallholders deploy various strategies to reduce the impacts of extreme weather events on their farming activities. Coping strategies are reactive and frequently used for the short term. For example, livestock and crop smallholder farmers in the Western Cape were selling livestock, buying feed, and transporting water from alternative sources to cope with the 2015–2018 drought scenario (Pili & Ncube, 2022; Fanadzo et al., 2021). Antwi-Agyei & Nyantakyi-Frimpong (2021) learned that smallholders in Ghana were dependent on social capital, non-farm jobs, and the selling of livestock and other resources that they owned to cope with climate hazards. These types of coping strategies are unsustainable in the long run for low-resourced farmers. However, adaptation is the most preferred strategy since it helps smallholder farmers

to build long-term resilience to harsh weather patterns. Coping strategies can also be beneficial as a temporary measure to withstand the challenge while looking for suitable adaptation strategies. Adaptation strategies are usually aimed at achieving long-term benefits and can be deployed as a proactive strategy or as an immediate response to a hazard (Osman-Elasha et al., 2005).

Adaptation means adjusting practices to withstand anticipated environmental changes and their effects (IPCC, 2014). The goals of adaptation is to prevent or minimise harm and to leverage potential benefits (IPCC, 2014). The lack or limitation of adaptation strategies increases the vulnerability of smallholder farmers to extreme weather conditions.

2.7.1 Review of adaptation and coping strategies for crop production

There is a combination of strategies adopted by smallholders to lower the impact of climate disasters on farm productivity and livelihood. Shikwambana & Malaza (2022) revealed that smallholders in Limpopo resorted to diversifying earnings, delaying cultivation, and choosing early maturing and drought-tolerant crops. Changing planting times is motivated by trends in climate, for example, late precipitation. Smallholder farmers relying on rainfall for crop irrigation find themselves in situations where they need to align their planting dates with shifting rainy seasons. Etongo et al. (2022) reported similar strategies in the Seychelles, where smallholders adapted by moving planting dates, planting trees, shading crops, using compost, and irrigation.

Thinda et al. (2020) reported that smallholders who were beneficiaries of the land reforms adapted to changing climate and extreme weather events by taking insurance covers for disaster, conserving water, planting trees, and relocating. Smallholder farmers plant trees to protect crops and livestock against extreme weather conditions such as heat waves. Tree planting is recommended for offsetting carbon dioxide, which is among the gases that contribute to global warming.

According to the results reported by Popoola et al. (2018) smallholder farmers in the Eastern Cape responded to the impact of extreme weather conditions on agriculture by harvesting rainwater, changing planting dates, and practising mixed cropping. Shisanya & Mafongoya (2016) highlighted that smallholders preferred using more than

one strategy, such as taking insurance cover, using fertilisers, and changing farming practices to minimum tillage. The strategies adopted by farmers depended on socioeconomic factors such as education, age, and income, among other things (Shisanya & Mafongoya, 2016).

In Mpumalanga, smallholder farmers reportedly practised mulching, minimum tillage, planting crop covers and increasing irrigation to adapt to a changing climate (Nkosi et al, 2023). However, Fouotsa et al (2022) found that increasing irrigation during drought did not yield a quick recovery to impacts on crop productivity. The smallholder farmers are integrating both indigenous and modern strategies to adapt to climate extremes, such as rainfall prediction, on-farm diversification, fertilisers, cultivating exotic plants, and using climate information for on-farm decision-making (Rankoana, 2022). Other strategies include delaying cultivations, changing farm practices, planting drought-tolerant crops, and diversifying on-farm activities (Antwi-Agyei & Nyantakyi-Frimpong, 2021).

Kom et al. (2023) focused on the indigenous knowledge strategies adopted by smallholders in Limpopo to adapt to extreme weather events. Their results showed that smallholder farmers used indigenous knowledge to predict rainfall. Smallholders use both the scientific and indigenous strategies to adapt their farming practices to environmental change. Elum et al. (2017) reported modern strategies that were used by smallholder farmers to adapt, such as pest management, moving crops, and diversification of farm activities.

2.7.2 Adaptation and coping strategies for livestock

Smallholders are implementing multiple strategies to manage the impact of extreme weather events on livestock. Thinda et al. (2020) report that farmers opted to reduce their livestock production to cope with climatic disasters. In the face of the changing climate, smallholder farmers cannot afford to keep much livestock because of the burden of finding effective adaptation measures (Maluleke et al., 2020). Destocking is common among smallholder farmers when faced with the challenges of grass and water shortage during drought (Bahta, 2020; Mokwena & Maluleke, 2017). However, Mdiya et al. (2023) show that farmers coped by separating grazing camps, dipping,

buying lucerne, and vaccination. Only a small fraction of smallholder farmers can purchase supplements owing to affordability issues.

Rakgwale & Oguttu (2020) showed that, despite relying on government relief programmes, smallholder farmers were also drilling boreholes to get water for livestock. However, their adaptation strategies remained limited, and they resorted to unplanned selling and slaughtering of livestock either to buy supplements, reduce the cost of maintenance, or prevent the loss that comes with mortalities (Rakgwale & Oguttu, 2020). Popoola et al. (2019) confirmed that the adaptation measures of smallholder farmers are very narrow. This can be attributed to a lack of resources to purchase advanced technology and build infrastructure. As a result, the smallholder farmers relied on cutting down production and relying on social relief assistance (Popoola et al., 2019).

2.8 Constraints for adaptation

Smallholder farmers struggle to adapt to climate change and drought, with other farmers having little or no strategies. A study by Pili & Ncube (2022) in the Western Cape found that most smallholder farmers lacked knowledge of adaptation measures. In Limpopo, Rapholo & Makia (2020) found that 36% of farmers could not identify changes in climate conditions correctly. This may have an impact on their ability to adapt to climate disasters. For example, in another finding, Myeni & Moeletsi (2020) highlighted that climate change awareness was a key driver of the adoption of adaptation strategies in smallholdings. Access to climate information could help smallholder farms adapt to climate change effectively.

However, Ncoyini et al. (2022) found that the farmers were reluctant to use climate information to support farm decisions. Therefore, it was concluded that perceived usefulness and lack of education may have limited the farmers from accessing and utilising valuable climate data. Accessing climate information could assist farmers in preparing for disasters before they happen. Nonetheless, smallholder farmers require training and development to make sense of climate data and adapt their farming practices. Shisanya & Mafongoya (2016) contend that to respond to climate change, smallholder farmers should adopt effective farming practices. This emphasises the

importance of smallholder farmers having appropriate training to enhance their skills and farm effectively in the face of climate change.

Smallholder farmers face numerous challenges constraining their ability to effectively adapt to climate shocks and hazards. This includes agricultural water shortage, limited access to land, and insufficient institutional support (Slayi et al., 2023). Access to irrigation water is a challenge in smallholder agriculture, leading to the reliance on rainfall for production, which is becoming scarce under climate change. Furthermore, access to productive farming land in South Africa is not easy, especially among smallholder farmers. This constrained smallholder farmers from adapting to climate change through the intensification of farm production. Most institutional support provided to smallholders is aimed at providing short-term relief and fails to make long-lasting change. Government programs that focus on skills development and climate change awareness in smallholder farming have been suggested to build capacity for adaptation (Thinda et al., 2020).

Shikwambana & Malaza (2022) looked at the adaptation methods implemented by smallholders in Vhembe and Mopani districts during drought. Their findings highlighted that the adaptation capacity of smallholders was low due to a lack of awareness, poor farming skills, low government support, and limited market access. As usual, Shikwambana & Malaza (2022), in the same study, observed that smallholders relied on government relief programs to manage the impacts of drought. Although institutional support is key in the development of smallholders, there is a need for farmers to adopt diverse strategies to build resilience against climate disasters. The government relief program is aimed at providing a temporary solution and is not sustainable in the long term.

Smallholder farmers still struggle to access extension services and modern technology limiting their adaptation options (Popoola et al., 2020). Increasing access to extension services in smallholder farming to support climate adaptation has been suggested (Shisanya & Mafongoya, 2016). Ubisi et al. (2017) support this by highlighting that the level of adaptation improved among smallholder farmers with access to extension services. Other studies reported that the adaptation methods of smallholder farmers were constrained by a lack of access to social networks, financial capital, physical assets, and human capital (Popoola et al., 2020; Olabanji et al., 2021). Based on the

studies reviewed this far, smallholder farmers in South Africa experience similar challenges in terms of access to resources regardless of their institutional settings and arrangements.

2.9 Chapter summary and conclusion

Smallholder farming in South Africa provides food and income to many households. The literature above aimed to analyse the impacts of extreme weather conditions on water resources, crops, and livestock production in smallholder farming. The impacts on the livelihood of farmers were identified. The literature suggests that due to climate change and drought, smallholder farmers experienced increased temperature, low rainfall, frequent drought episodes, pests, and disease outbreaks. These impacts led to farmers experiencing water shortages, veld deterioration, crop failures, livestock mortalities, loss of income, food insecurity, and mental stress. Additionally, smallholder farmers adopted multiple strategies to cope and adapt to climate hazards and shocks. However, their strategies were limited because of resource constraints, such as a lack of training, insufficient support, and a lack of awareness. This study sought to close some gaps in the literature by exploring the impacts of climate change and drought on water availability in smallholder farming and the resultant effects on farm productivity and livelihood.

CHAPTER THREE: RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

This chapter discusses the research design and methodology adopted. It starts by describing the study site to give the reader an idea of where the research was conducted. Subsequently, outline the research design, data collection process, and sampling procedure. It concludes by giving details of data analysis techniques and ethical requirements that were observed throughout the study process.

3.2 The study area

The study area was Overberg District Municipality (ODM), which is based in the Western Cape province. The ODM is found in the southern part of the Western Cape. District municipalities in South Africa comprise more than one municipality. The function of the district municipality is to run the administration of the district and to support local municipalities in providing service delivery to communities. The ODM covers an area of 12,241 km² and includes four municipalities, which are the Overstrand, Cape Agulhas, Swellendam, and Theewaterskloof (WCG, 2017). Areas covered in the Overberg region for data collection were Bredasdorp, Napier, Elim, Caledon, Tessaarsdal, Swellendam, Genadendal, Suurbraak, Buffeljagsrivier, and Villiersdorp. Farming is a predominant activity in these towns.

The latest statistics revealed the total population of ODM was 359,446 people in 2022 and was expected to increase by at least 8.8% by 2027 (WCG, 2023). The unemployment in ODM was lower than that of other districts and the province, sitting at 14.9%. Agriculture in Overberg and the entire province contributes substantially to employment creation. However, there were limitations to the reporting of unemployment in Overberg because the survey adopted a limited definition of unemployment, which focused only on the number of people actively applying for jobs but not able to find work (WCG, 2023). Therefore, it does not consider those who want employment but are not actively looking owing to various circumstances. Smallholder farmers in Overberg employ themselves on the farms and also seek work outside their farms to diversify their incomes.

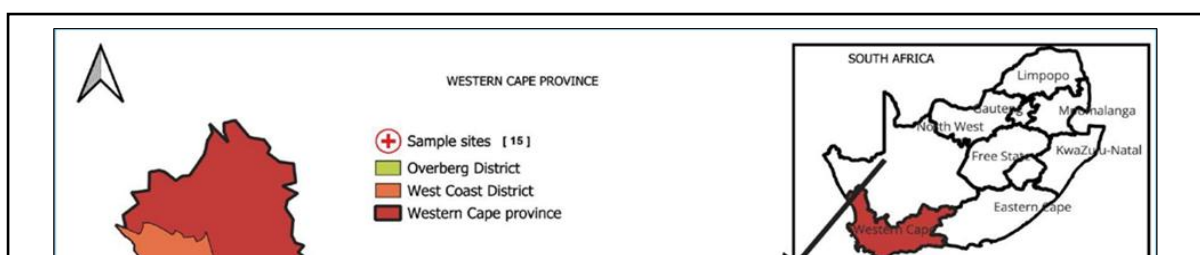


Figure 3.1: A map showing the study area (Source Ncube et al., 2025)

The climate in the Overberg region is Mediterranean, characterised by warm and dry summers and cold and wet winters. The regional climate forecast estimates an average temperature increase of 3°C by 2060 in these areas (WCG, 2017). Rainfall is also uncertain as it is expected to decline in winter months (mid-May to August) and increase in summer (December to January). This means climate change is likely to cause a shift in planting seasons because rain-dependent farmers would expect to receive more rain in winter months, but it is shifting to summer. This emphasises the need to make climate information available to adapt effectively to climate change. The following hazards: drought, floods, storms, erratic rainfall, and changes in seasons have been identified in the Overberg related to climate change (WCG, 2017). The identified risks include infrastructure damage, food and water insecurity, health crises, impacts on natural resources, and reduced investments. The water resources in Overberg include rivers, boreholes, springs, Riviersonderen and Elandskloof dams.

3.3 Research design

Research design encompasses the strategies for collecting, presenting and analysing the data to achieve the study. The objectives of the study shape the design and can be based on qualitative, quantitative, or a combination of these approaches (Creswell & Creswell, 2014). This study employed a concurrent mixed-methods design. This

design integrates the aspects of qualitative and quantitative approaches simultaneously in one or more stages of the investigation (Levanon et al., 2021; Mohammadi et al., 2020). In addition, both aspects of qualitative and quantitative data are treated with equal importance.

In this study, a mixed-methods design was employed concurrently in both stages of data gathering and analysis. The motivation for adopting a mixed-method approach was that a single research approach (qualitative or quantitative design) could not address the research problem adequately. In addition, a concurrent mixed-method design enables triangulation and the collection of complementary data (Levanon et al., 2021).

3.3.1 Quantitative research design

Quantitative research can either be descriptive to identify relationships between variables or experimental to determine interrelationships (Mehrad and Zangeneh, 2019). Quantitative research gathers and analyses data numerically to measure variables and test objectives (Creswell & Creswell, 2014). Quantitative research is guided purely by statistical models to collect and analyse information objectively, which eventually increases the generalisability of the results from the sample to the entire population (Mulisa, 2022). It relies on large datasets to generate inferences, focusing on how much data is collected instead of the depth of that data (Mulisa, 2022). A standardised survey questionnaire with closed-ended responses is a common instrument used for collecting quantitative data. Choy (2014) ascertained the benefits of using quantitative methods are easy to administer, and one can gather reliable data very quickly. However, this does have some limitations which relate to the explanation of participants' experiences in a deeper sense. Quantitative data in this study were collected from smallholder farmers through a survey questionnaire.

3.3.2 Qualitative research design

Qualitative research focuses on exploring and analysing individual perceptions and experiences of a phenomenon under investigation in its natural context (Cresswell & Creswell, 2014). Qualitative research is based on the constructivist paradigm (Heigham & Croker, 2009). The philosophical assumption of the constructivism

paradigm is that humans construct knowledge through interaction with the real world (Heigham & Croker, 2009). Therefore, there is no universal reality; rather, each person has a different experience of the world based on their circumstances. Constructivists posit that there are multiple realities, and they are context-based. Hence, it is also proposed in this study that smallholder farmers are not uniform. Therefore, their experiences of climate change and drought may not be the same, considering their different socioeconomic standings and institutional arrangements.

Qualitative researchers focus on the lived experiences of the participants. The goal of this study was to understand the impacts of climate change and drought on smallholder farm productivity through the lens of the participants. Qualitative research emphasises including those who are affected in the investigation of the problem to gain a deeper understanding. Therefore, a phenomenological qualitative research design was deemed suitable for this study. The phenomenological research approach focuses on people's encounters with the problem as framed and understood by them (Creswell & Creswell, 2014). The qualitative research approach collects data that is in words to gain in-depth insight into the phenomenon under investigation (Creswell, 2014). Qualitative research is exploratory and can lead to the construction of new ideas and theories.

Qualitative research has faced criticism for being subjective, failing to test assumptions, and lacking the strength to generalise the findings (Mulisa, 2022). However, generalisation is not the main aim of qualitative research. Instead, it focuses on providing deeper insights about participants' experiences in the natural setting. Hence, qualitative studies are not affected by the sample size. Despite the challenges, qualitative studies provide the best approach for a broader understanding of a research problem because it is an open-ended inquiry that allows for the exploration of diverse views (Choy, 2014). Qualitative data were gathered using a survey questionnaire with open-ended questions, interviews, and follow-up focus group discussions. The qualitative element focused on climate and drought perceptions on agricultural water and farm productivity.

3.4 Data collection procedure and instruments

3.4.1 Survey questionnaire

A survey questionnaire (Appendix II) was used to collect data from smallholder farmers to understand the impacts of extreme weather events on their farm productivity, livelihood, and social well-being. The survey questionnaire also focused on collecting data on smallholder farmers' characteristics, such as gender, age, education, capital assets, farming practices, and household information. Data on perception regarding agricultural water availability and access, and their coping and adaptation strategies adopted to reduce the impacts of extreme weather events on farm production was also gathered using the survey questionnaire.

The questionnaire was designed with both open and closed-ended statements to collect quantitative and qualitative data concurrently. The questionnaire was administered by conducting face-to-face interviews with smallholder farmers. All interviews were recorded with permission granted by the participants through a signed consent form. The Centre for Disease Control (2018) highlighted that questionnaires are advantageous under resource constraints, especially when data is needed from a larger population. To ensure validity and reliability, the questionnaire was pre-tested to modify questions that were not clear. The survey questionnaire data were anonymised by assigning a unique number and managed in an Excel spreadsheet before they could be processed for data analysis.

Inclusion and exclusion criteria

Participants were eligible for inclusion in the survey if they met the following criteria:

- They were smallholder farmers who were actively engaged in crop and/or livestock farming.
- Were at the age of 18 years or older.
- Were willing to participate and provide informed consent voluntarily.

The following individuals were excluded from the survey:

- They were not actively engaged in farming at the time of conducting the study.

- They were commercial farmers involved in large-scale production.

3.4.2 Focused Group Discussion

Smallholder farmers who participated in the survey were later invited to take part in Focus Group Discussions (FGDs). The FGDs were conducted as a follow-up strategy to clarify issues that emerged during the survey and to widen the scope of data collection for deeper analysis. The FGDs were open dialogue with the researcher guiding the discussion using semi-structured questions (See Appendix III). The FGDs offered a unique approach to capturing participants' perceptions on the effects of extreme weather conditions on water availability and effects on farm productivity in smallholder farming systems. Perceptions on current and future adaptation strategies were considered among the key questions discussed.

A total of eight FGDs were conducted in each site within the broader study areas. The FGDs in each site were conducted by bringing farmers together at the central location, where the researcher facilitated the discussions. During the FGDs, each participant was allowed to present their views on issues being discussed and any other matters that emerged. The discussion took place in local community churches and halls. Transportation was arranged to bring the farmers to the central location. This was done to ensure that all participants had a fair chance of partaking in the discussion. Each focused group discussion involved a minimum of 10 participants. The FGD data were transcribed and managed in a Microsoft Word file and stored in a secure folder before being processed for data analysis. This data was anonymised by removing details that could lead to the identification of any of the participants.

3.4.3 Semi-structured interviews

Semi-structured interviews (Appendix IV) were conducted with 13 key informants from local key organisations working directly with smallholder farmers and institutions responsible for the management of water resources to understand climate change and drought effects on water availability. The local organisations interviewed include the local church working with smallholder farmers and institutions such as the Breede-Olifants Catchment Management Agency (BOCMA), the Department of Agriculture in the Western Cape, local municipalities, water boards, and water conservation groups.

These were key role players, and their participation in the study provided valuable insight into the research problem. The Interviews played a crucial role in gaining deeper information about participants' knowledge, views, feelings, beliefs, and interests (Kindon et al., 2007). The interviews created a space for the participants to express themselves.

A semi-structured interview can be described as a logical dialogue with the researcher having questions in mind to cover the research topic, but at the same time creating an opportunity for the interview to take an unpredictable direction that might lead to uncovering new information (Adeoye-Olatunde & Olenik, 2021). This means the interviewer sets questions to guide the discussion, but also allows respondents to provide input that may assist in achieving a comprehensive understanding of the research problem. In this study, the semi-structured interviews focused on gathering deeper information on drought occurrences, impacts on the water availability and resultant effects on productivity, including trends in the past 20 years.

The semi-structured interviews were conducted in-person and online via Zoom video conferencing. All interviews were recorded using an electronic device and transcribed for data analysis, with the participants' permission. Informed signed consent was obtained before the commencement of the interviews. The data were transcribed and managed in a Microsoft Word file and stored in a secure folder before being processed for data analysis. This data was anonymised by removing details that could lead to the identification of a particular participant.

Key informants were included if they were representative of key local water and agricultural-related institutions, and community-based organisations working with smallholder farmers. These institutions were key to include because of their direct involvement in water and agriculture management, and providing support to smallholder farmers, especially in the context of climate disasters.

3.5 Sampling

The study target population was smallholder farmers in ODM and key informants from key local institutions. The sampling strategy employed in the study was the non-probability method. This sampling strategy does not offer each case in the population

an equal opportunity to be selected. The participants are chosen by the researcher, referred by someone, or volunteer themselves (Stratton, 2021). Different non-probability sampling styles exist. The most popular ones are purposive sampling, convenience sampling, and the snowball sampling technique (Stratton, 2021).

In this study, 100 smallholder farmers and 13 key informants were purposively selected. Key local institutions working with smallholder farmers were identified and recruited through a letter to participate in the interviews as key informants. Regarding the selection of smallholder farmer participants, a list of farmers was obtained from the local Department of Agriculture, with contacts and names. Initial contacts were made with smallholder farmers to arrange for site visits and interviews through agricultural extension officers. The agricultural extension officers were key in identifying smallholder farmers and arranging meetings for interviews.

However, the lists obtained from the Department of Agriculture did not produce an adequate number to reach the required sample for the study, especially for the statistical analysis. This could be because some of the smallholder farmers were not receiving support from the Department of Agriculture. Therefore, they could not be located in their database. To increase the sample, an additional number of smallholder farmers were recruited through farmers who were the initial contacts, known as the snowball sampling strategy. This was key to accessing an additional number of smallholder farmers.

The two sampling methods used in this study were purposive and snowball sampling. Key informants were selected using purposive sampling. Smallholder farmers were selected using purposive sampling as the first strategy, followed by snowball sampling to increase the number of participants. These were qualitative sampling techniques that used non-randomised methods to select participants. Non-probability sampling methods are subjective; however, they are important approaches to use as they allow the researcher to select participants based on how they can benefit the study, especially the purposive recruitment (Palinkas et al., 2015). This sampling technique is critical under resource constraints because suitable participants can be recruited quickly.

Snowball sampling refers to a sampling technique of identifying participants to solicit information from and ask them to refer other suitable candidates (Kennedy-Shaffer et al., 2021). Snowball sampling is also referred to as referral sampling. While non-probability sampling has been criticised for being less objective and limited in generalisability, it still holds several benefits, including obtaining rich data (Kennedy-Shaffer et al., 2021).

3.7 Data analysis

Data analysis is more about giving meaning to the data. Statistical Package for Social Sciences (SPSS) was used to perform descriptive analysis. It was used to describe the distribution and relationship among variables. The quantitative data were analysed and presented in the form of charts, tables, and graphs. On the other hand, ATLAS.ti software was used to perform thematic analysis on qualitative data. Kiger & Varpio (2020) contend that thematic analysis is the most suitable approach for analysing perceptions, experience, connections or contrasts in qualitative data. Thematic analysis involves searching, verifying, determining, and analysing trends, connections, or contradictions in participants' responses to report about them (Braun & Clarke, 2006). The steps for performing a thematic analysis, as outlined by Braun & Clark (2006), were followed for qualitative data analysis:

3.7.1 Familiarise with data

The first step of the analysis was understanding the data. It involved reading the transcripts and formulating an understanding of the data. Braun & Clarke (2006) emphasised that researchers should familiarise themselves with the data before they start analysing.

3.7.2 Generate codes

The second phase involved organising the data and transforming it into categories by assigning codes. In this study, codes were generated manually by reading through the data line by line, searching for meaningful patterns. An inductive approach to thematic analysis was adopted, which involved reading the transcripts to highlight meaningful segments. This means the codes were generated from the participants' responses.

3.7.3 Search for themes

The third phase of the analysis involved checking the codes and searching for themes. This was done by manually checking for connections in the data to develop themes.

3.7.4 Review themes

Examining the theme thoroughly to determine if they are suitable and correspond with the data. Themes that were not meaningful were discarded or modified.

3.7.5 Define and name themes

The fifth step includes describing themes generated from the data. The generated themes were defined for data analysis and presentation.

3.7.6 Write a report

Writing the report is the last step of thematic analysis. It includes the presentation and interpretation of the findings under themes.

3.8 Data reliability, validity, and trustworthiness

Reliability is concerned with the consistency of the measure, while validity is concerned with its accuracy. To maintain reliability and validity in this study, the data collection tools, which included the interview questions and the survey questionnaire, were pre-tested before the start of the data collection process. This was achieved by doing a pilot study. The goal was to check the content validity of the questions. Furthermore, all questionnaires were checked manually to ensure the correct capture of the data. Trustworthiness focuses on the truthfulness of the research findings. To maintain trustworthiness, four criteria proposed by Lincoln and Guba (1986) were followed.

3.8.1 Credibility

The concept of credibility deals with the consistency of the measures to ensure that the study evaluates what it intends to inquire about and gives a true reflection of the situation or problem being investigated. To increase credibility, Lincoln and Guba

(1986:77) suggested prolonging engagements with participants, constant observations, data triangulation, checking of participants, and analysis of negative cases.

3.8.2 Confirmability

The concept of confirmability ensures the rigour of the study by eliminating researcher biases (Lincoln & Guba, 1986). The researcher must be objective throughout to maintain trustworthiness. The study was conducted under strict ethical research conduct. The investigator abides by the ethical and moral values of research by remaining truthful throughout the research stages. Participation in this study was under strict confidentiality to enable participants to express themselves fully.

3.8.3 Transferability

The concept of transferability deals with the possibility for the findings of the study to be applied in a different context, area, or individual group (Lincoln & Guba, 1986). It seeks to answer the question of whether the results can be transferred whole group or to other populations in different settings. Larger sample sizes are the most preferred strategy to enable the generalisation of the findings. In this study, data were obtained from 100 participants to enable drawing inferences. Further, data were gathered from suitable respondents sampled purposively to eliminate the possibility of collecting unreliable and inaccurate data.

3.8.4 Dependability

The concept of dependability focused on the reliability and validity of the data (Lincoln & Guba, 1986). It asks the question of whether similar findings of the study can be repeated if another research study is conducted on the same sample. In this study, dependability was maintained by outlining the details of the methodology used throughout the research process.

3.9 Ethics statement

This study acknowledged and adhered to the following ethical considerations:

Ethical clearance

This study obtained ethical clearance before the commencement of data collection. A formal application was made to the Cape Peninsula University of Technology (CPUT) research ethics committee, and ethical approval was granted for the thesis (Appendix V).

Informed consent

Merriam & Tisdell (2016) emphasised the importance of obtaining informed consent because it enables participants to make informed decisions regarding their participation in the study. It also allows them to accept or decline participation (Merriam & Tisdell, 2016). Participants in this study were provided with a written informed consent (Appendix I). The study's purpose, procedures, risks, and benefits were explained to the participants. Furthermore, the participants were allowed to ask questions about the study and the nature of their participation. Thereafter, the researcher proceeded to ask for permission to interview the farmers. Those who agreed to participate were required to sign a consent form before they could be interviewed.

Voluntary participation

Merriam & Tisdell (2016) assert that research studies should consider and acknowledge the right to withdraw consent at any stage when participants decide not to continue with the study. Participation in this study was entirely voluntary. Therefore, the participants were made aware that they could choose to withdraw their consent at any stage without any penalty or prejudice.

Privacy

Privacy involved not sharing participants' identities or personal information, especially without their consent or permission. Wittich, Boie, & Jaiswal (2023) emphasised that participants should be guaranteed their right to privacy. The researcher should make sure that the rights of the participant to privacy are not invaded during and after the research by keeping participants' information confidential and anonymous. Confidentiality in this study was maintained through the non-disclosure of participants'

information in a way that violates the rights of participants, and that may leave participants exposed to any kind of vulnerability.

The data was managed in a secure folder on a laptop with a password. The voice recordings were also password-protected. The data was anonymised to protect the privacy of the participants. The data collected was treated with strict confidentiality. All parties involved in the handling of the data were required to sign a non-disclosure agreement form. Confidentiality was further maintained by not capturing or presenting the names or home addresses of the respondents; by doing so, responses will not be traceable to any respondent.

3.10 Limitations of the study

Like any other research, this study has limitations. A list of farmers to interview was provided by the Department of Agriculture in the Overberg region. However, the list was not inclusive of the diverse group of smallholder farmers. Only farmers receiving support or working directly with extension officers were on the list. This limitation was addressed by snowball sampling, which involved asking the participants to recruit other farmers.

Furthermore, a notable number of smallholder farmers were not fluent in English. These farmers were either isiXhosa or Afrikaans speaking. A research assistant, who was appointed to work on the main project, assisted with translation for isiXhosa, and the extension officers assisted with translation for Afrikaans during interviews and focus group discussions.

3.11 Chapter conclusion

This chapter has described the study site, followed by the research methodology, sampling procedures, data collection strategy, analysis techniques, ethics statement, and study limitations. The following chapter presents and discusses the study's findings.

CHAPTER FOUR: FINDINGS AND DISCUSSION

4.1 Introduction

The previous chapter presented the methodological approach and data collection procedure. This chapter presents and discusses the results obtained from the survey questionnaires, focus group discussions, and key informant interviews to answer the other three key research objectives of the study, which are:

- *Explore the impacts of climate change and drought on agricultural water availability and access in smallholder farming in the Overberg District, Western Cape.*
- *Investigate the effect of climate change and drought on smallholder agricultural productivity and its impact on the livelihood and well-being of smallholder farmers in the Overberg District, Western Cape.*
- *Identify and analyse the strategies implemented by smallholder farmers to minimise the effects of climate change and drought on farm productivity.*

The first section focuses on the characterisation of respondents, followed by their perceptions of climate change and its effects on water availability and farm productivity. Thereafter, the measures adopted by the respondents to reduce the impacts of climate disasters are presented and discussed

4.2 Characteristics of smallholder farmers

4.2.1 Age

Figure 4.1 shows participants' age distribution. Most participants (about 37%) were between the ages of 51 and 65 years, and about 34% were in the age category of between 36 and 50 years. About 19% of farmers were 66 years old and above. Only 10% of farmers were in their youth (18–35 years). Similarly, Fanadzo et al. (2021) reported a smaller number of youths involved in smallholder farming in the Overberg District. Even in other provinces, smallholder farming is usually dominated by older people, especially those above the age of 60, who are mostly pensioners (Olabanji et al., 2021; Ubisi et al., 2017). This suggests that only a few youths are involved in

smallholder farming. During the focus group discussion (FGD) in Ganedendal, one participant commented on the low participation of youth in farming:

“The government is saying uplift youngsters, but the youngsters are not interested in farming (FGDP1).”

Inadequate representation of youth in farming raises a concern for the future of agriculture in the country. For example, one participant (Farmer **GenOD20**), who was 70 years old and farming on a land size of less than a hectare, was not willing to expand farming activities owing to old age. This could mean agricultural activities might decline as smallholder farmers age unless the youth are encouraged to participate in farming. A study conducted in the province of KwaZulu-Natal found that most of the youth were not interested in primary agricultural activities because they were physically demanding (Geza et al., 2023). However, they would rather participate in agri-processing and distribution for a quicker return on investment. This suggests youth participation in agriculture should not only focus on farm production but on the entire value chain.

Chipfupa & Tagwi (2021) cautioned against using a blanket approach towards the discussion of youth involvement in agriculture, arguing that not all young people have negative perceptions. Furthermore, these researchers observed that access to resources influences the perceptions of the youth about venturing into agricultural business. Designing specific agricultural programmes for youth and education training is suggested as one of the solutions to the underrepresentation of young people in farming (Geza et al., 2023).

Nonetheless, paying attention to the age distribution of the participants was also crucial in explaining the perceived shift in climate patterns for the past 20 years, which was among the key focuses of the study. Older participants tend to have a greater insight into long-term changes in climate patterns and past disasters, as they have lived through such conditions. For example, one older participant, who was 52 years of age, expressed that, every 20 years, they experience a storm that causes damage to infrastructures such as roads. The recent storm they experienced, according to this participant at the time of these discussions, was in 2019.

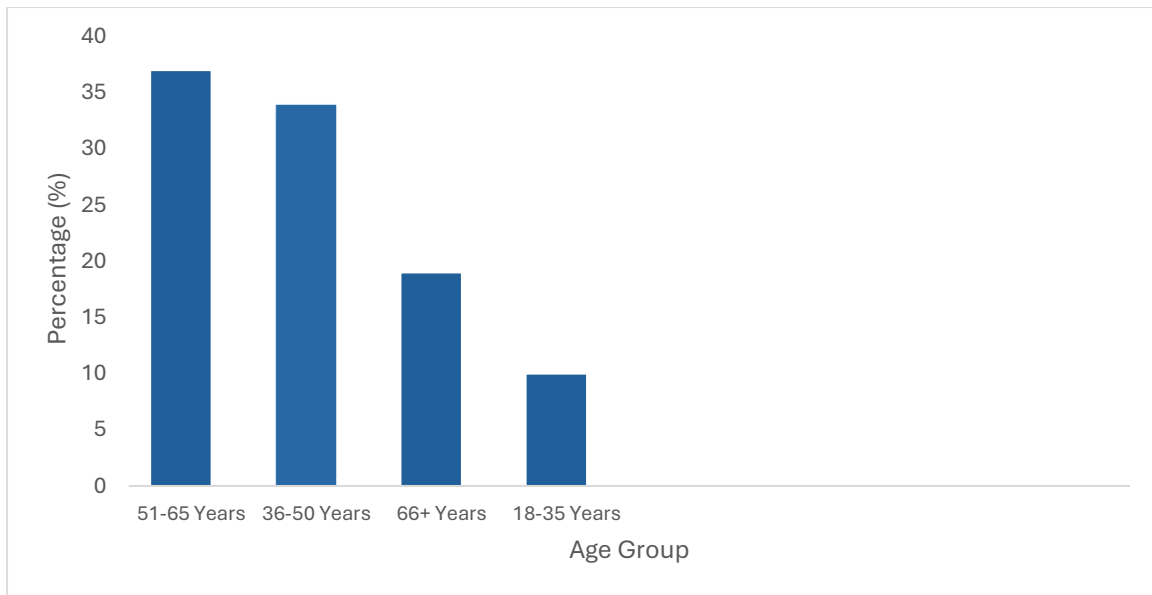


Figure 4.1: Age grouping of smallholder farmers in Overberg District (n=100)

4.2.2 Gender

Regarding gender, male farmers were dominant, representing 76% of the sample. Only 24% of farmers interviewed were female (Figure 4.2). This could be a result of methodological bias, specifically the non-probability sampling strategy used in this study to select participants. However, Pili & Ncube (2022) reported similar findings in the Overberg District, where 82% of farmers interviewed were male. Similarly, Olabanji et al. (2020) reported that there were more male than female farmers in their study conducted in Mpumalanga. Even in other African countries, Asia, and South/Central America, it is common for male farmers to outnumber female farmers in smallholder agriculture (Bako et al., 2022; Harvey et al., 2018; Landaverde et al., 2022; Shukla et al., 2019). Nonetheless, different results were found in Limpopo, where 64% of smallholders were female (Ubisi et al., 2017). As alluded to above, the gap in gender participation in this study could be because of the bias of purposive and snowballing sampling methods. However, in any case, limited participation of women in smallholder agriculture could exacerbate gender disparity in rural economic development.

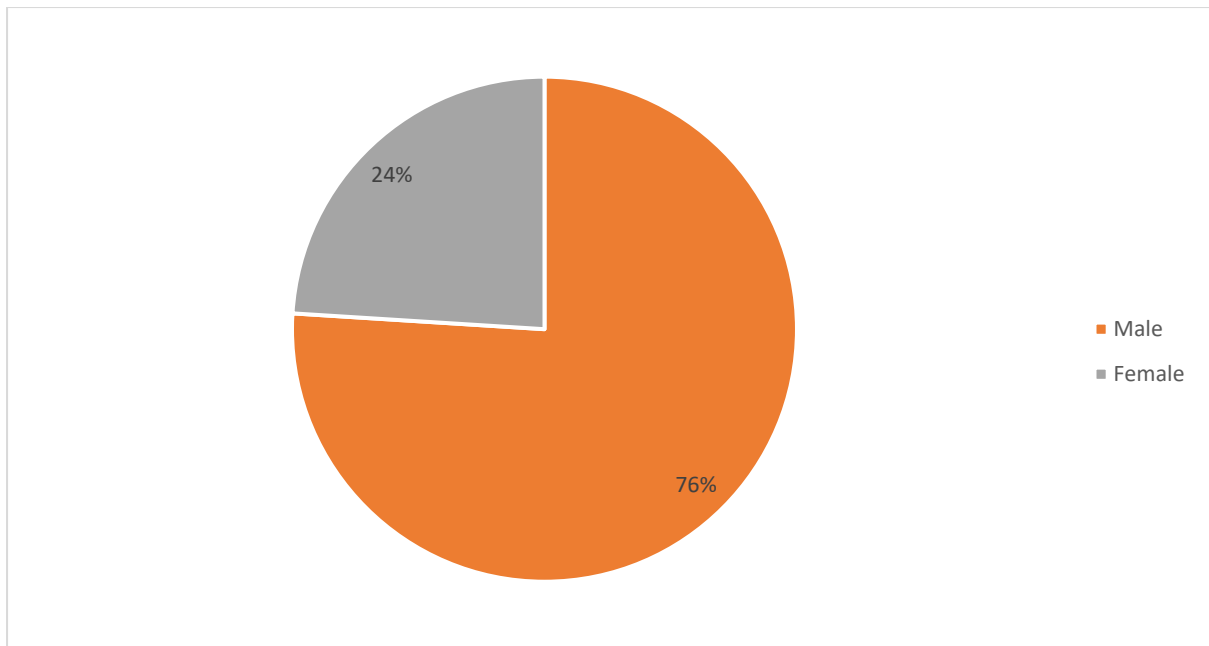


Figure 4.2: Gender distribution of participants (n=100)

4.2.3 Household sizes

Regarding household sizes, Figure 4.3 indicates that 48% of farmers lived in a family of four to six members, followed by 42% of farmers from households that comprised one to three members. Farmers who had seven or more members in the household were fewer, with 10% representation. Twecan et al. (2022) reported similar results in Uganda, where most farmers were from households of between four and six members. Household size is important human capital for smallholders relying on family labour (FAO, 2013). This suggests that households with more members may have enough labour needed on their farms. In addition, they can cope better with the effects of harsh weather conditions on farm productivity and income by participating in off-farm employment and combining their income to make a living (Fernández et al., 2019).

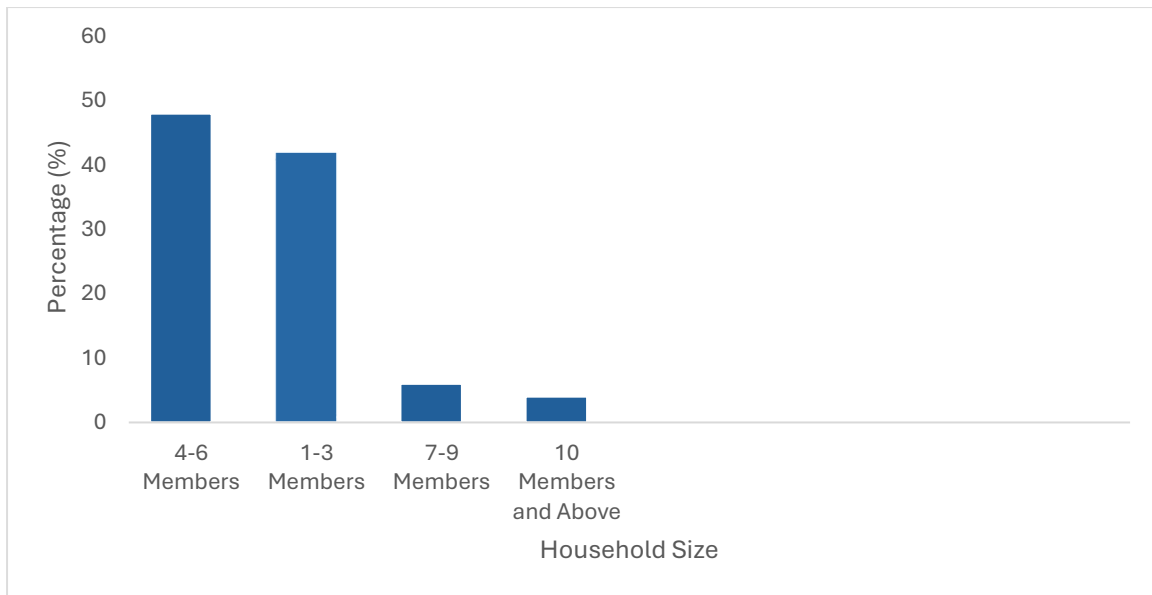


Figure 4.3: Household sizes of smallholder farmers in Overberg District (n=100)

4.2.4 Level of education

Figure 4.4 indicates that 32% of smallholder farmers attended secondary school but did not complete matric, and about 22% only had a primary school education. Only 30% of farmers had matric as their highest level of education. Despite having a relatively lower level of education, a few farmers (about 7%) had diplomas, a postgraduate degree (1%), and post-matric certificates (6%). Only one farmer out of 100 participants reported not having a formal education.

Shikwambana & Malaza (2022) reported similar findings in the Limpopo province, where only 11% of smallholder farmers studied beyond matric. Smallholder farmers usually have a low level of education (Mamun et al., 2021; Matlou et al., 2021). For instance, in Central America, Harvey et al. (2018) discovered that 54% of the smallholder farmers they interviewed lacked primary education. In this study, the limited level of education may be due to the age of farmers, who are dominated by older people. Most farmers were born during the apartheid system of racial segregation, where education opportunities were limited.

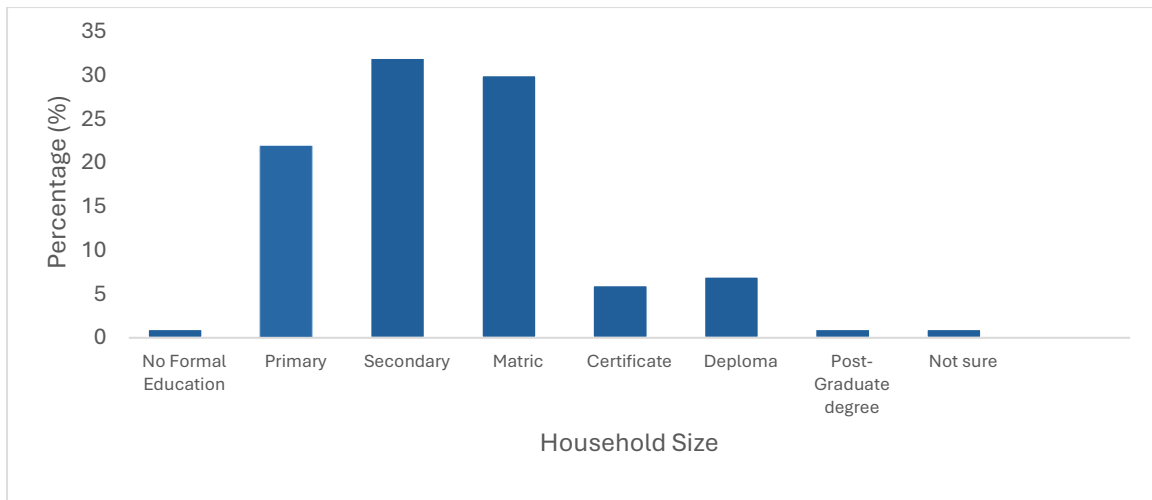


Figure 4.4: Smallholder farmers' level of education in Overberg District (n=100)

4.2.5 Years of farming

Farming experience is crucial for smallholder farmers to acquire essential farming skills and adapt effectively to changes in climate conditions. Figure 4.5 indicates that 23% of the participants reported having less than five years of experience in farming, while 36% had between 5-10 years, 14% had 11-15 years, 6% had 16-20 years, 10% had 21-25 years, and 11% had 26 years and above. A notable proportion of the participants indicated considerable farming experience.

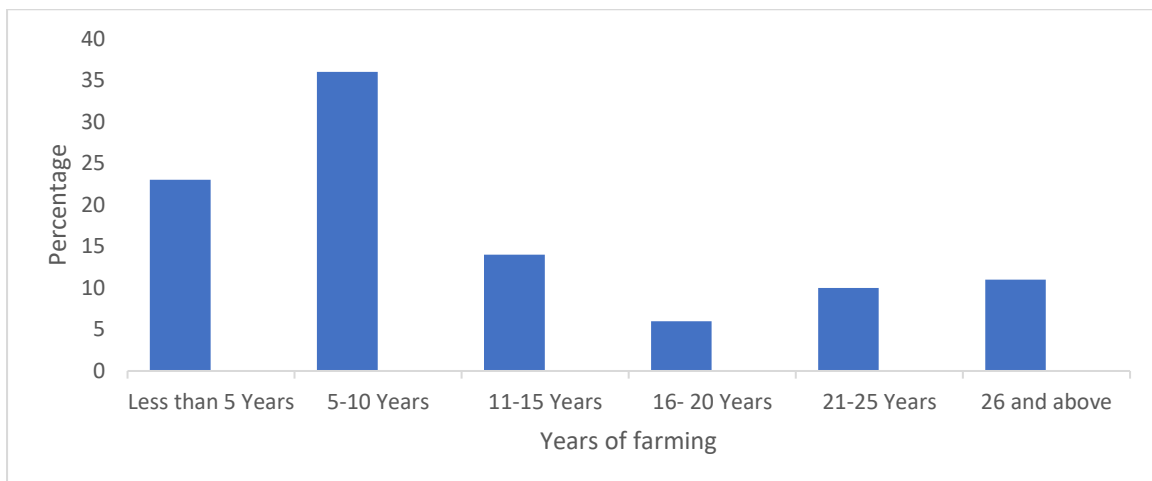


Figure 4.5: Years of involvement in farming for smallholder farmers in Overberg District (n=100)

4.2.6 Land sizes

The size of farming land is commonly used to characterise or define a smallholder farmer. Smallholder farmers are known for practising on a land size of less than a hectare but can farm up to 10 hectares (FAO, 2013). About 48% of the respondents reported land sizes of less than a hectare (Figure 4.6). Large land sizes are crucial for smallholder farmers to expand their farm production, including the transition to commercial farming. Furthermore, about 22% of the participants reported having a land size of between 1ha and 10ha, 9% (11ha to 20ha), 8% (21ha to 30ha), and 10% (31ha and above). About 3% of the respondents were uncertain about the sizes of their land, as shown in Figure 4.6 below.

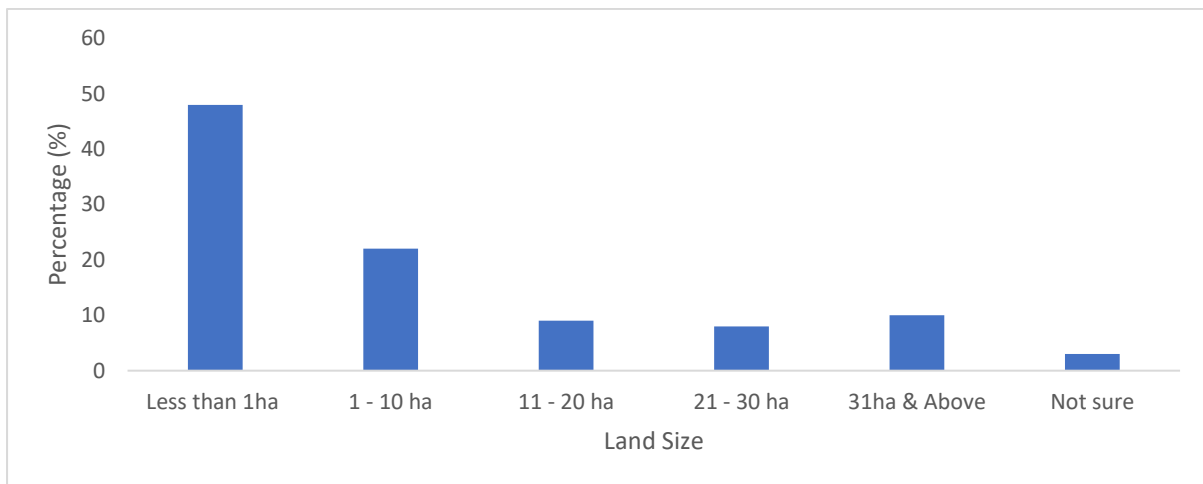


Figure 4.6: Land size distribution among smallholder farmers in Overberg District (n=100)

4.2.7 Land tenure

The participants' means of access to land for farming was mostly by allocation (39%), either from the municipality or the local authority that oversees water rights and land allocations. Similar findings were reported in China, where 94% of smallholder farmers indicated they acquired farming land through government allocation (Pickson & He, 2021). This is contrary to the study carried out in Bangladesh, where most of the smallholder farmers owned land (Mamun et al., 2021). Other means of access to farming land for the respondents included 18% inheritance, 18% borrowing, 12% renting, and 6% buying. Finally, 7% of the participants did not specify. Figure 4.7 illustrates the mechanisms by which respondents accessed land.

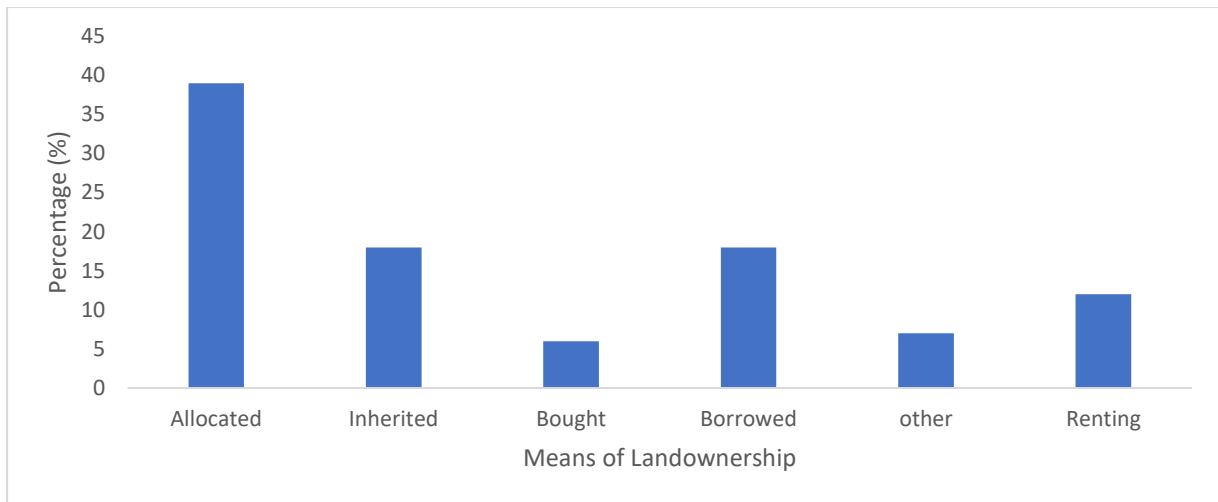


Figure 4.7: Smallholder farmers' means of land ownership in Overberg District (n=100)

The status of land ownership in Overberg is complex. In some towns, the land ownership belongs to the municipality, while in other areas the land belongs to the church or is in the custodianship of the Minister of Land and Rural Development. One participant expressed frustration with barriers to accessing land for farming:

“I often wonder how the government can provide us with water infrastructure when we don't have access to land. Therefore, it's crucial to resolve the land issue first, which would enable us to access water infrastructure (Farmer S NapOD41).”

Those who were allocated pieces of farming land by the municipality had lease agreements of 9 years and 11 months. In towns where the land was under the custodianship of the national government, like in Genadendal, local committees have been established to oversee land-related issues. Such land was described by the participants as communal land, and they had an agreement to lease the land for up to 99 years.

However, not all participants leasing land had formal written agreements. Figure 4.8 shows that 45% of participants had written lease agreements, while 31% did not, and 22% had some form of agreement. A lease agreement is important as it gives farmers a secure land tenure.

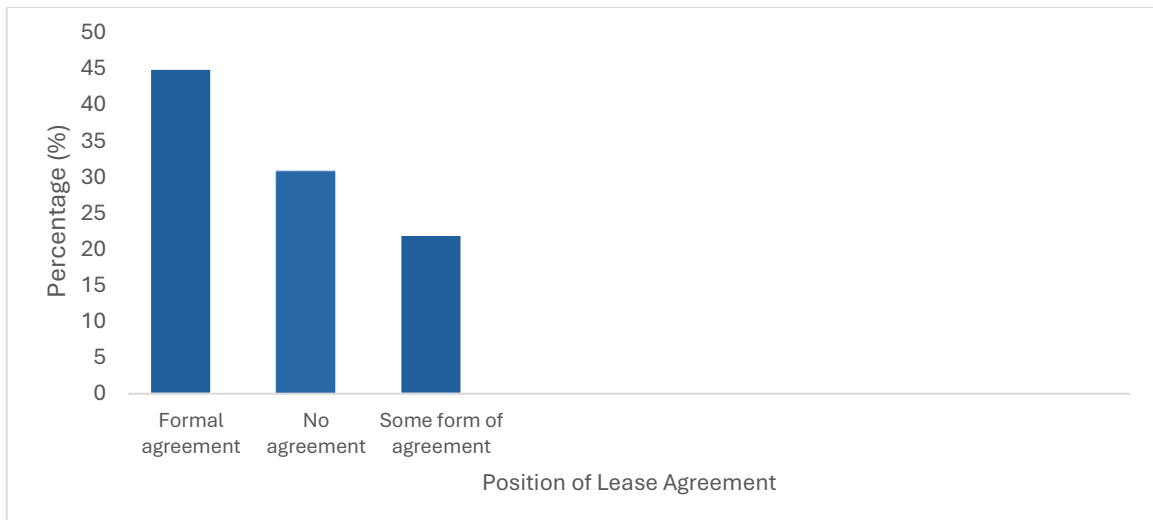


Figure 4.8: Distribution of lease agreement among smallholder farmers (n=100)

4.2.8 Types of farming

The study identified various farming enterprises practised by smallholder farmers. Figure 4.9 shows that livestock production accounted for 41%, crops 33%, and mixed farming 26%. The main crops produced by smallholder farmers were mostly vegetables. The smallholder farmers might have chosen to venture into vegetable production because it requires minimal irrigation and is easy to maintain. Other crop enterprises included flowers, fruits, and barley.

Livestock production was primarily focused on pig enterprises, with a few farmers also raising goats, sheep, chickens, and cattle. A pig enterprise can be managed on a small plot. This could be the reason most farmers were venturing into pig farming. Mixed farming systems are reported to enhance the adaptive capacity of low-resourced farmers (Mthembu & Zwane, 2017).

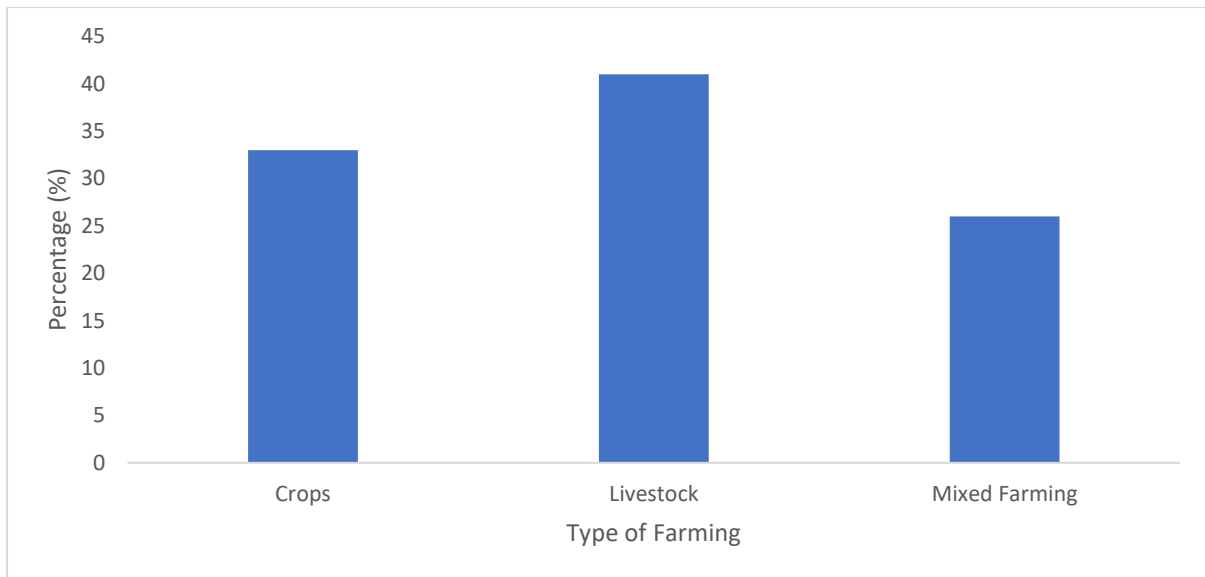


Figure 4.9: Smallholder farming practices in Overberg District (n=100)

4.2.8 Primary purpose of farming

Smallholder farmers have various reasons for farming, which are used as an attribute for their classification. Figure 4.10 indicates that 43% of smallholder farmers were farming mainly for markets, 42% were farming for family consumption and selling surplus, 15% were farming for family consumption. This finding is consistent with the characterisation of smallholder farmers by the government as individuals who produce for household use and sell surplus to generate an income (DEFF, 2015).

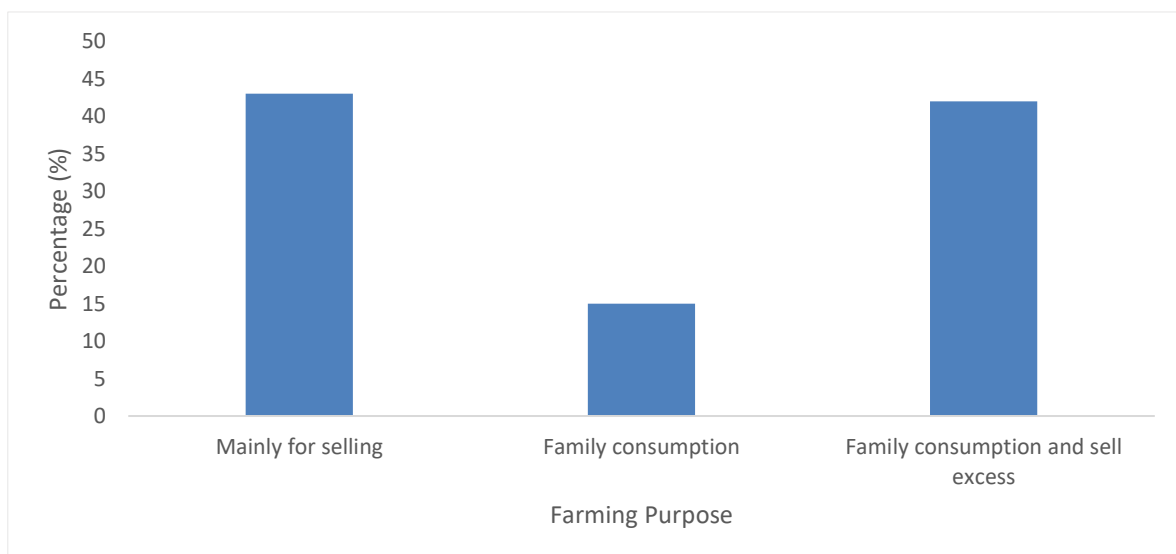


Figure 4.10: Smallholder farmers' purpose of farming in Overberg District (n=100)

4.2.9 Adequacy of farming land

Smallholder farmers in this study were asked whether their land was enough or not for their farming activities. Out of 100 participants, half (50%) said they had enough land for farming, and the other 50% said the land was inadequate. During the survey interviews, some farmers indicated that they needed extra pieces of land to expand their farming activities. These farmers expressed:

*“I would greatly appreciate the opportunity to acquire more land, which would allow me to expand my farming endeavours into livestock farming (Farmer **SNapOD38**).”*

*“I am looking for land to expand farming. The current land is not safe for keeping livestock (Farmer **SNapOD45**).”*

Challenges experienced by smallholders in South Africa include limited access to adequate, productive land for farming. Smallholders require sufficient land to farm productively. While access to bigger land sizes was a challenge, smallholders in Overberg owned bigger plots, in some instances, but were only utilising a small portion for farming.

4.2.10 Farming methods

Figure 4.11 shows the distribution of farming methods. Most of the respondents (72%) were farming individually, while 28% were farming in groups. During the FGDs, some farmers indicated that they formed cooperatives to farm in groups. Cooperatives are favourable and are prioritised in government funding, mainly owing to their potential for being successful. Farmers in cooperatives bring diverse skills and knowledge, which they combine to make their enterprises successful.

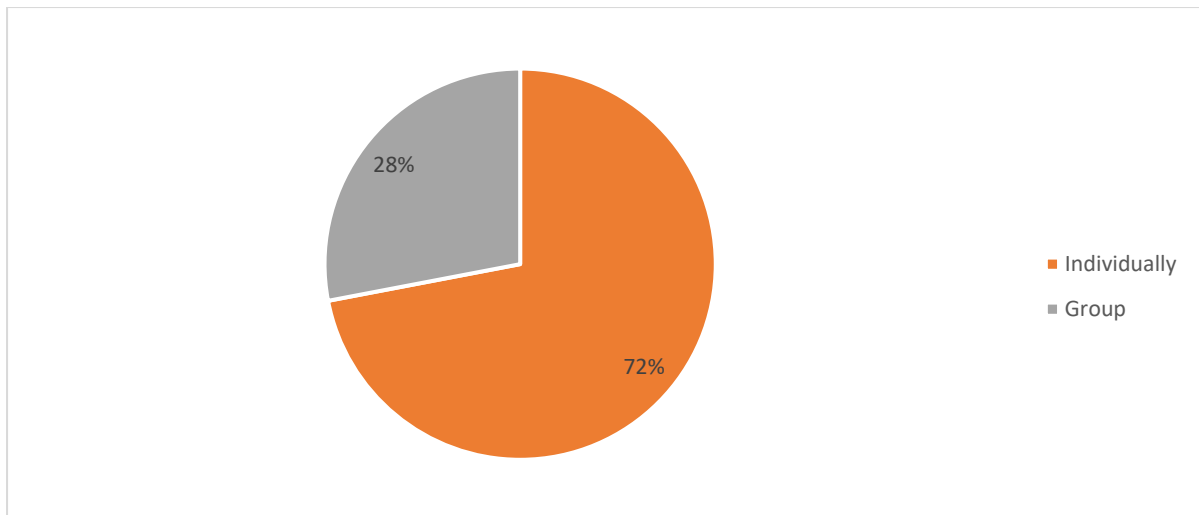


Figure 4.11: Farming methods among smallholder farmers (n=100)

4.2.11 Access to credit

Concerning access to credit facilities, only 16% of the respondents indicated “yes” to access (Figure 4.12). A study carried out in the Free State reported similar results of smallholder farmers interviewed, 98% had never accessed credit to invest in their crop production owing to old age, low earnings, and a low level of education (Myeni et al., 2019). Furthermore, similar results were reported in Nigeria, where 71% of smallholder farmers interviewed were excluded from accessing credit from financial institutions. (Bako et al., 2022). Access to finance is key to improving productivity in smallholder agriculture. However, smallholder farmers remain excluded from accessing credit. Farmer **SGenOD51**, when asked about access to credit, expressed:

“The land is under the minister’s trust; therefore, we cannot go to the bank to ask for financial assistance.”

The farmers believed that having land ownership could help them access loans from credit providers. Land ownership is usually used as collateral when farmers apply for loans. This study revealed that only a few farmers owned land. Possible reasons for a lack of access to credit despite having land ownership could be a lack of title deeds. The government tends to allocate land to disadvantaged individuals, including smallholder farmers, without providing title deeds.

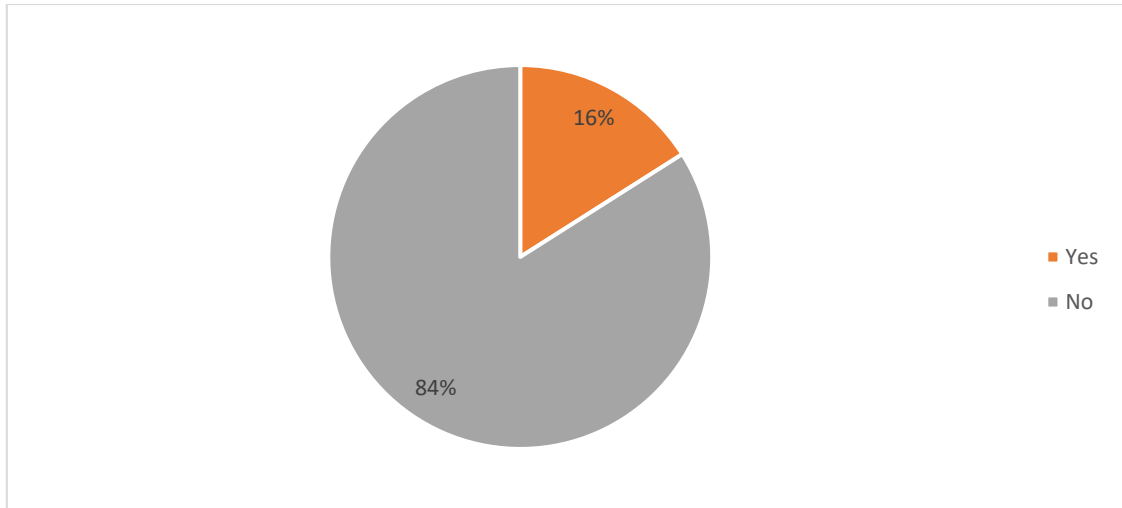


Figure 4.12: Smallholder farmers' status on access to credit (n=100)

4.3 Smallholder farmer climate change perceptions

4.3.1 Understanding of climate change and drought

Figure 4.13 indicates that most participants understood drought as a period of water shortage (39%), lack of rain (38%), dry period (13%), dry land (4%), warming (4%), and lack of feed for livestock (2%). This understanding is consistent with the characteristics of drought, as discussed in the literature. In 2015–2018, there was a drought in the Western Cape. It affected crop and livestock production mainly owing to water shortage, especially in smallholder agriculture, where irrigation water is lacking or limited (Pili & Ncube, 2022). This could be a possible reason why smallholders are familiar with drought.

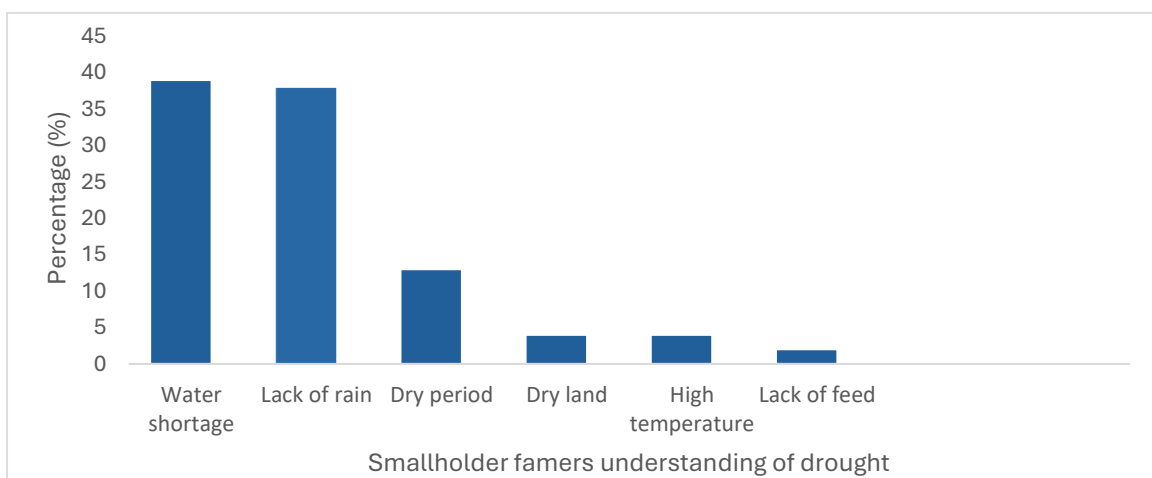


Figure 4.13: Distribution of participants' understanding of drought (n=100)

Figure 4.14 indicates that about 39% of the respondents understood climate change as a change in the weather. Other participants said climate change means temperature variation (26%), seasonal changes (16%), increased warming (10%), increased rainfall (7%), and environmental change (3%). As broad as their understanding is, the respondents showed some level of comprehension of climate change compared with the current working definition of the IPCC (2021).

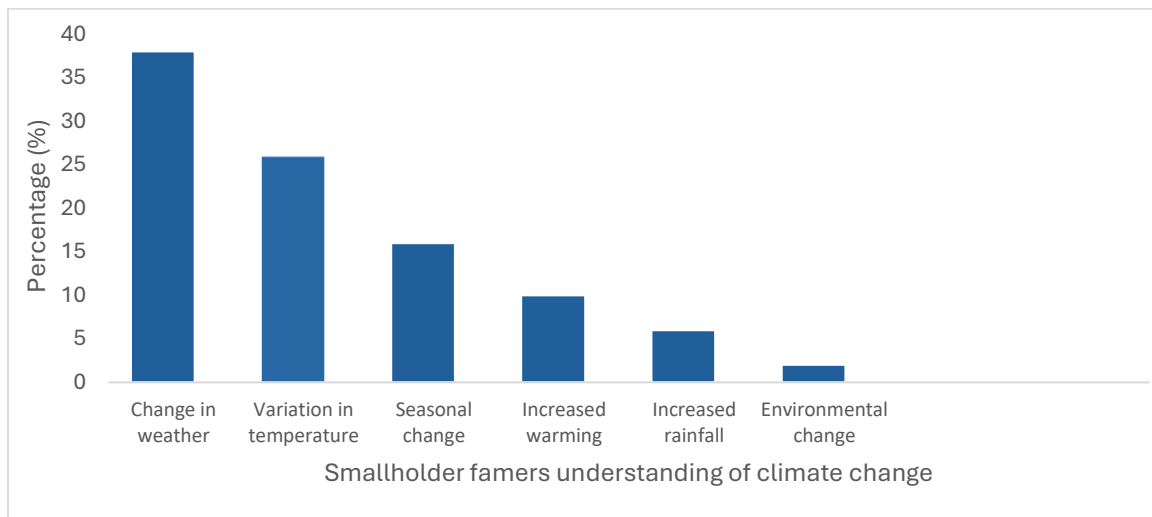


Figure 4.14: Distribution of participants' understanding of climate change (n=100)

4.3.2 Climate change and drought information sources

Access to weather information is important to help smallholder farmers prepare for climate disasters (Ncoyini et al., 2022). Olabanji et al. (2021) identified a lack of access to climate information as one of the barriers to smallholder farmers' adaptation to climate change. Table 4.1 indicates that the most common sources of climate information were television (30%), radio (18%), extension services (11%), the internet (9%), social media (8%), and farmers' unions (8%). Most households in South Africa, about 90%, have access to television (Illidge, 2024). This could be the reason they were the most common sources of climate information. Extension service appeared among the least used sources of climate information for smallholders. A few extension officers were attending to more farmers. This was observed during the data collection and site visits with extension officers from the Department of Agriculture. Increasing the number of extension officers could enhance information access in smallholder farming.

Table 4.1: Various sources of climate change and drought information

Sources of weather information	Frequency (N)	Percentage
Television	62	29.8
Radio	38	18.3
Social media	16	7.7
Internet	18	8.7
Farmers' unions	17	8.2
Newspaper	7	3.4
Extension services	22	10.6
Family and friends	9	4.3
Workers	7	3.4
Other	12	5.8
Total	208	100

The findings correlate with previous studies, which identified radio and television as the most common sources of climate information for smallholder farmers (Ncoyini et al., 2022; Myeni & Moeletsi, 2020; Popoola et al., 2020). These media sources are cheaper and can disseminate information quickly to a wider audience, including smallholder farmers. However, Popoola et al. (2020) argue that radio and television only provide farmers with weather information that is based on short-term forecasts, and they do not offer any suggestions on agricultural management practices. This renders the information provided unreliable and irrelevant for assisting smallholder farmers to cope and adapt to climate disasters (Popoola et al., 2020). There is a need for tailored climate information, along with practical recommendations, regarding farm management practices.

4.3.3 Perceptions of rainfall and temperature

Figure 4.15 presents participants' perceptions of temperature and rainfall changes for the last 20 years. Regarding temperature changes, 68% of the participants reported an increase, 15% reported a decline, and 13% reported no change. Regarding rainfall, 51% of participants reported an increase, 29% noted a decline, and 16% observed no change. Finally, 4% of the participants were not aware of any change in temperature and rainfall.

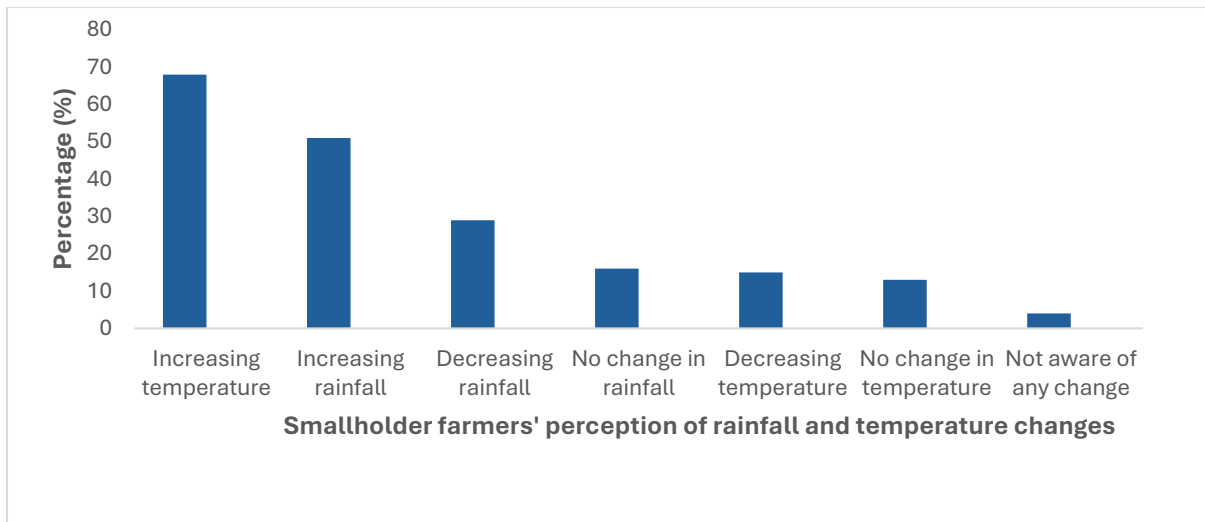


Figure 4.15: Smallholder farmers’ perceptions of temperature and rainfall changes (n=100)

During the FGD in Elim, the respondents indicated that they started experiencing more hot days in winter, unlike before. This was consistent with the responses of most participants on temperature changes. The views of the participants are elaborated on in their quoted statements:

“We see the change in heat and warmth because all of a sudden, we get warmer days in winter than before (FGDP1).”

“I think 2014/15. We recorded the hottest days, the warmest days in June, when the temperature was almost 30 degrees, and that was very unlikely because we receive winter rainfall in this area. I grew up in this town. So, I know exactly the patterns (FGDP3).”

“Nowadays, it becomes hotter during the day and in the seasons, and I think climate change has a great effect on the seasons in this area (FGDP2).”

Furthermore, during the FGD in Bredasdorp, the participants revealed that rainfall is increasing, and its pattern is changing. One participant indicated that they used to farm throughout the year, but now this has changed because of inconsistent rainfall. What follows are excerpts from participants’ statements:

“We are also privileged to have a weather station at the police station. It measures our rainfall (FGDP3).”

“Our rainfall is above 600 millimetres now. And that’s a lot of rain (FGDP1).”

“Yes, definitely there is a change; we used to get rainfall throughout the year (FGDP2).”

The views of smallholder farmers on changes in climate conditions can provide valuable data to inform future adaptation strategies. In Nepal, Dahal et al. (2023) learned that smallholder farmers’ observations of changes in temperature and rainfall aligned with meteorological data of the area. Mamun et al. (2021) found similar results in Bangladesh, where the observations of smallholder farmers were correlated with weather-related information regarding changes in warming and precipitation. Similarly, Shukla et al. (2019) in India reported that the perception of smallholder farmers correlated with long-term meteorological data. Likewise, in Uganda, smallholder farmers’ observation of climate patterns was consistent with secondary climatic data registered over 10 years. This indicates that farmers have knowledge of the long-term variations in climate conditions, which may assist them in adapting their farming practices and improving productivity.

4.3.4 Temperature and rainfall measurements

Participants were asked if they were recording temperature and rainfall data. Figure 4.16 shows that 86% of participants had no measuring device. Only 14% of participants reported using rainfall and temperature gauges to take measurements.

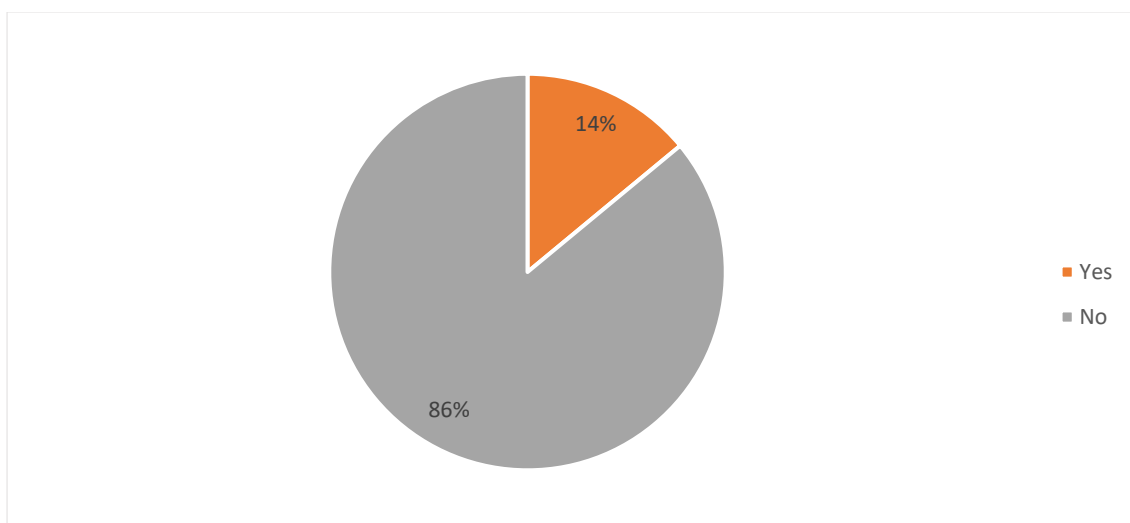


Figure 4.16: Smallholder farmers’ measurement of temperature and rainfall (n=100)

4.3.5 Other climate change-related events

Table 4.2 displays climate disasters experienced by smallholder farmers over the past 20 years. Floods (33%) and drought (29%) were more widely experienced than storms (15%), forest fires (12%) and heatwaves (11%). Drought is a common and regular element of the Western Cape climate (Botai et al., 2017). Drought and floods are natural disasters, but their frequency and intensity are projected to intensify with global warming (Trisos et al., 2022).

Table 4.2: Climate-related disasters experienced by smallholder farmers (n=100)

Climate change-related disasters	Frequency	Percentage (%)
Floods	57	33.1
Drought	50	29.1
Storms	25	14.5
Forest Fires	21	12.2
Heatwaves	18	10.5
Other	1	0.6
Total	172	100

4.4 Effects of climate change and drought on agricultural water availability

4.4.1 Water sources

The primary sources of water for smallholder farmers in this study were rivers (24%), dams (22%), and rainwater harvesting (20%). Springs and boreholes were the least-used water sources. The results of the water sources are shown in Table 4.3. While smallholder farmers are known for relying on rainfed agriculture, this was not the case in the Overberg District. Smallholder farmers had access to various water sources for livestock and crop irrigation. These findings do not coincide with previous studies conducted in Limpopo, which revealed that smallholder farmers mainly relied on rain for crop irrigation (Rankoana, 2022; Ubisi et al., 2017).

Table 4.3: Smallholder farmers' agricultural water sources (n=100)

Agricultural water sources	Frequency (N)	Percentage (%)
Fountain	13	8.5
River	37	24.2
Dam	33	21.6
Rainwater harvesting	30	19.6
Water Scheme	24	15.7
Streams	8	5.2
Spring	4	2.6
Borehole	4	2.6
Total	153	100

However, during the focus group discussion in Swellendam, farmers expressed a preference for rainwater harvesting to save costs on water fees. One farmer added that rainwater harvesting makes farming profitable compared to buying water for irrigation. Using rainwater could reduce the cost of irrigation, enabling smallholder farmers to have extra capital to invest in their farming business. One participant indicated:

“You have to use rainwater for the livestock and increase your profit, and it has a huge effect on your farming business. It has a huge impact if you don’t have rainwater on your farm. Like, I mean, even if scheme water is there, rainwater makes the business more profitable (FGDP5).”

4.4.2 Water use access mechanisms

There were four water authorisation processes through which smallholder farmers accessed agricultural water. These were licensed water use (38%), Schedule 1 approval (34%), municipal supply (20%), and general authorisation (8%) (Figure 4.17). According to South Africa’s National Water Act (Act 36 of 1998), there are four

categories of water use authorisation processes: Schedule 1, general authorisation, water use licence, and existing lawful use. Water use, under Schedule 1 and general approval, does not require an application for a licence. However, the water is used under certain prescribed limitations specified in Chapter Four of the National Water Act (1998). For example, Schedule 1 allows smallholder farmers to take water from any source for domestic purposes such as recreation, emergencies, gardening, and watering livestock (excluding commercial use) without paying fees or having a licence. Schedule 1 water use activities can commence without the smallholder farmer informing the relevant authority.

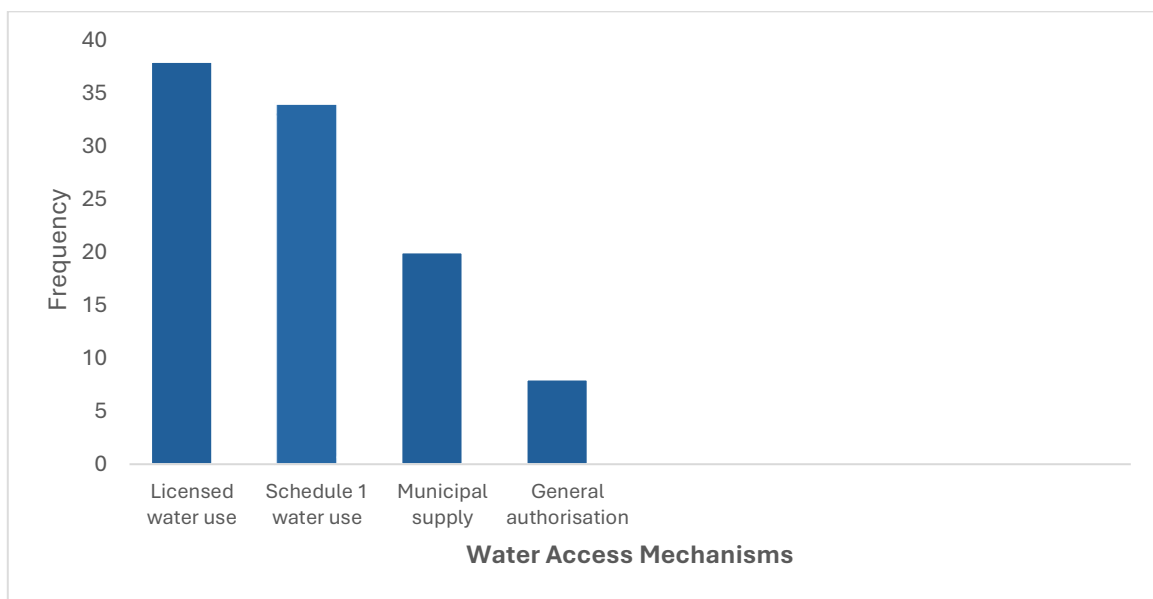


Figure 4.17: Smallholder farmers' mechanisms for accessing agricultural water (N=100)

However, the general authorisation water use category requires users to register water activities with the relevant government department. In this study, smallholder farmers obtained permission for general water authorisation from the municipality. The smallholder farmers who used water from the municipal supply inherently obtained water use rights and were liable to pay water fees, the same as the licence holders.

4.4.3 Cost of agricultural water

Figure 4.18 shows that 52% of respondents were not paying for agricultural water. The findings further revealed that 19% of respondents reported water costs above R1001 per month, while 15% paid between R101 and R1001. Among the remaining

respondents, 7% reported payments of between R501 and R1000, and another 7% paid between R1 and R100.

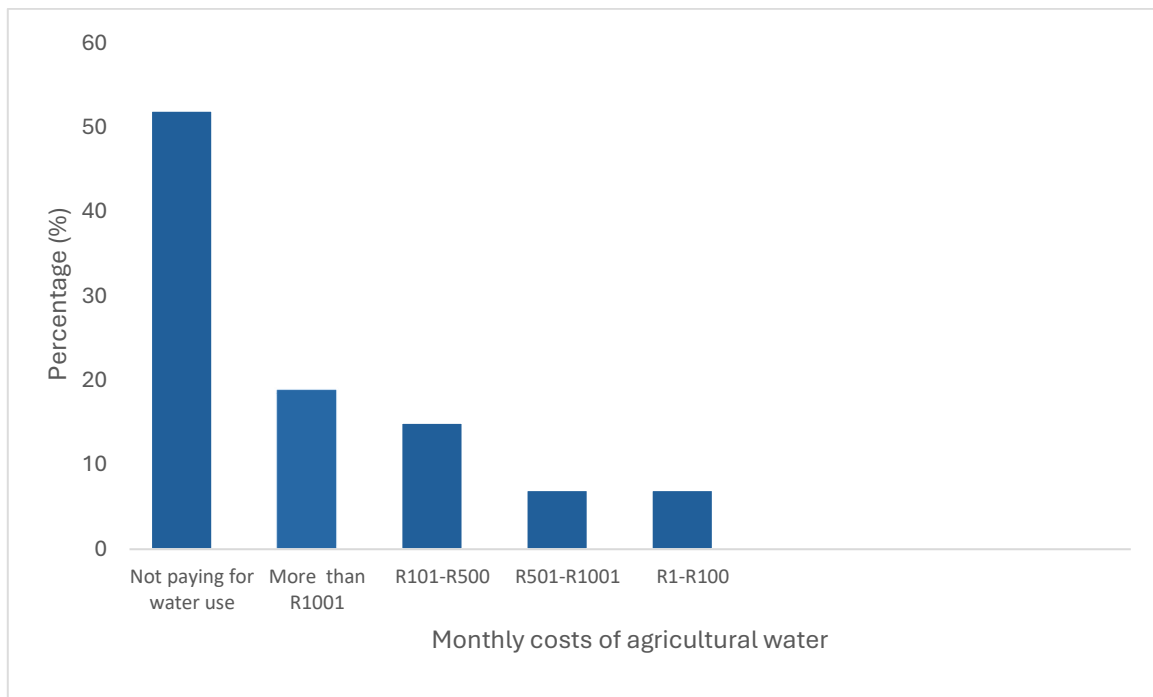


Figure 4.18: Cost of agricultural water (N=100)

The possible reason for non-payment of agricultural water by most of the respondents could be due to affordability issues. Most of the respondents were either pensioners, depending on old age grants, or did not have any other form of income. Those who were relying on rainwater harvesting for livestock and crop irrigation were not paying for water use.

4.4.4 Affordability of agricultural water

The smallholder farmers who were paying for agricultural water were asked whether they could afford to pay or not. It was found that 83% of smallholder farmers who were paying for agricultural water could afford to pay, and 17% could not afford it. The unaffordability of agricultural water impacts water access and farm production in smallholder farming. It also had an implication for farmers getting support from the Western Cape Department of Agriculture (WCDA). Farmers who were not paying for water use were excluded from getting government assistance. This decision was taken as measures to encourage smallholder farmers to pay for their water bills. Ncube (2018) revealed that inadequate access to agricultural water constrained the farm

productivity of smallholders in the Western Cape. Increasing water availability and access in smallholder agriculture is recommended to enhance farm production. Another constraint to agricultural water was the high fees for municipal water.

The respondents indicated during the FGD in Swellendam that municipal water was expensive compared to scheme water. This view is elaborated on by the excerpts from a participant's statements:

“The municipal water in Swellendam is more expensive than our water from Overberg. Overberg Water supply is a little bit less expensive (FGDP1).”

Most smallholder farmers were either pensioners or unemployed. Therefore, they relied on their small earnings from their farms and the old age grant to pay for agricultural water. It is then evident that paying for agricultural water had an impact on the income of smallholder farmers.

4.4.5 Climate change and drought impact on agricultural water availability

The respondents were asked whether they faced challenges of a water shortage over the last 20 years due to drought and climate change. About 65% of the participants responded 'yes', and 35% said 'no' (see below Figure 4.19).

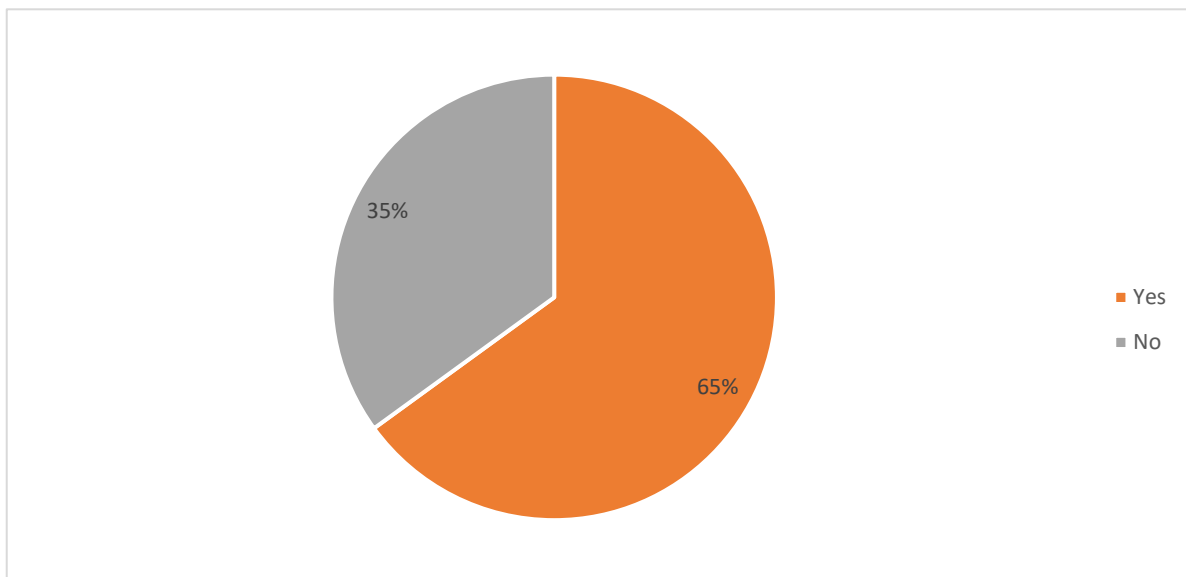


Figure 4.19: Smallholder farmers experiencing water shortage due to climate change and drought (n=100)

In other towns in the Overberg District, such as Genadendal, farmers indicated during a focus group discussion that they had never experienced a water shortage for agriculture because they had sufficient water in the mountains, and the rivers were always flowing. The participants expressed that:

“We don’t have a problem with water here, and we don’t have a problem with the weather because the sunny weather is good for us, and we have enough water, and our stuff can grow quickly (FGDP2).”

“We never really have a drought problem, not here, but we were close to it. I am 63 now, and I can’t recall, but they did not have water in Cape Town because they don’t go to church often. We go to church a lot, and we don’t have a problem with water. I believe in God. In 2018 and 2019, we were close to having a drought; things were tough here, but it was not bad, and we survived. I have never experienced drought here, but if it happens, it will be the first time (FGDP1).”

Nonetheless, most participants (65%) acknowledged that they had experienced water shortages as a result of the drought. During the focus group discussion in Elim, one participant expressed that, despite having abundant water resources, they were affected by drought:

“We are very privileged to live in a very water-rich area, but yes, there were times in the past 10 years when we were facing challenges during the drought period, when by the time there was talk about day zero. So, there was a shift; we were forced to make plans to get excess water for farming purposes (FGDP1).”

Recent studies (Pili & Ncube, 2022; Fanadzo et al., 2021) revealed that, in the Overberg region, smallholders experienced water shortages during the 2015–2018 drought. Botai et al. (2017), who focused on drought characterisation in the Western Cape, reported that water levels in most dams were reduced to below 30% during the 2015–2016 drought event. In a study conducted in the Northern Cape by Bahta & Myeki (2022), water shortage was among the challenges faced by smallholder farmers during drought. Similar results were reported in the Eastern Cape, where drought

reduced water availability for smallholder agriculture (Popoola et al., 2018). The participants who depended on rainfed agriculture noticed the effect of climate change on water accessibility. One farmer in Swallendam during a focus group discussion stated:

“Climate change has quite a huge impact on us because we don’t have access to municipal water; we only use rainwater (FGDP2).”

Similar impacts of climate change on water availability were observed in other provinces. In Limpopo, Maluleke et al. (2020) reported that the water sources that smallholder farmers relied on for livestock were dried up. In the same province, Louis & Mathew (2020) discovered that climate change restricted water availability in smallholder agriculture, depending on rainfall for crop irrigation. Similar results were also reported by Rankona (2022), where smallholder farmers perceived rainfall scarcity for crop irrigation owing to climate change.

Another climate disaster that affected water resources is floods. The key informants explained that they have experienced consecutive floods over the past four years in Overberg. These floods normally happen between January and March, and later in October and December. The key informants reported that floods affected water availability and access for smallholder farmers by damaging critical water infrastructure. Water pipes and irrigation systems were washed away during flooding. Figures 4.20 and 4.21 show the responses of key informants on the impacts of drought and floods on water availability in smallholder farming in the Overberg District.

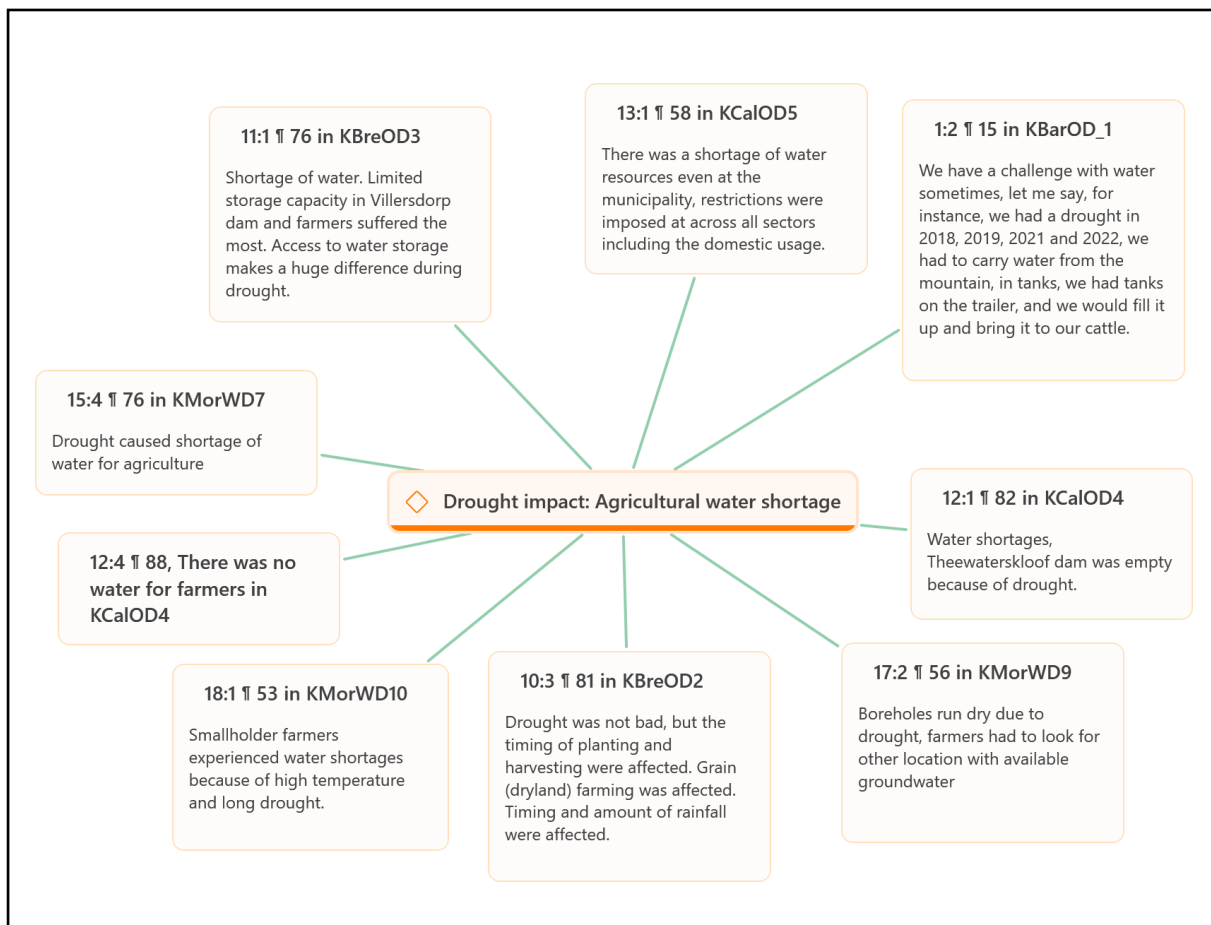


Figure 4.20: Impact of drought on agricultural water availability

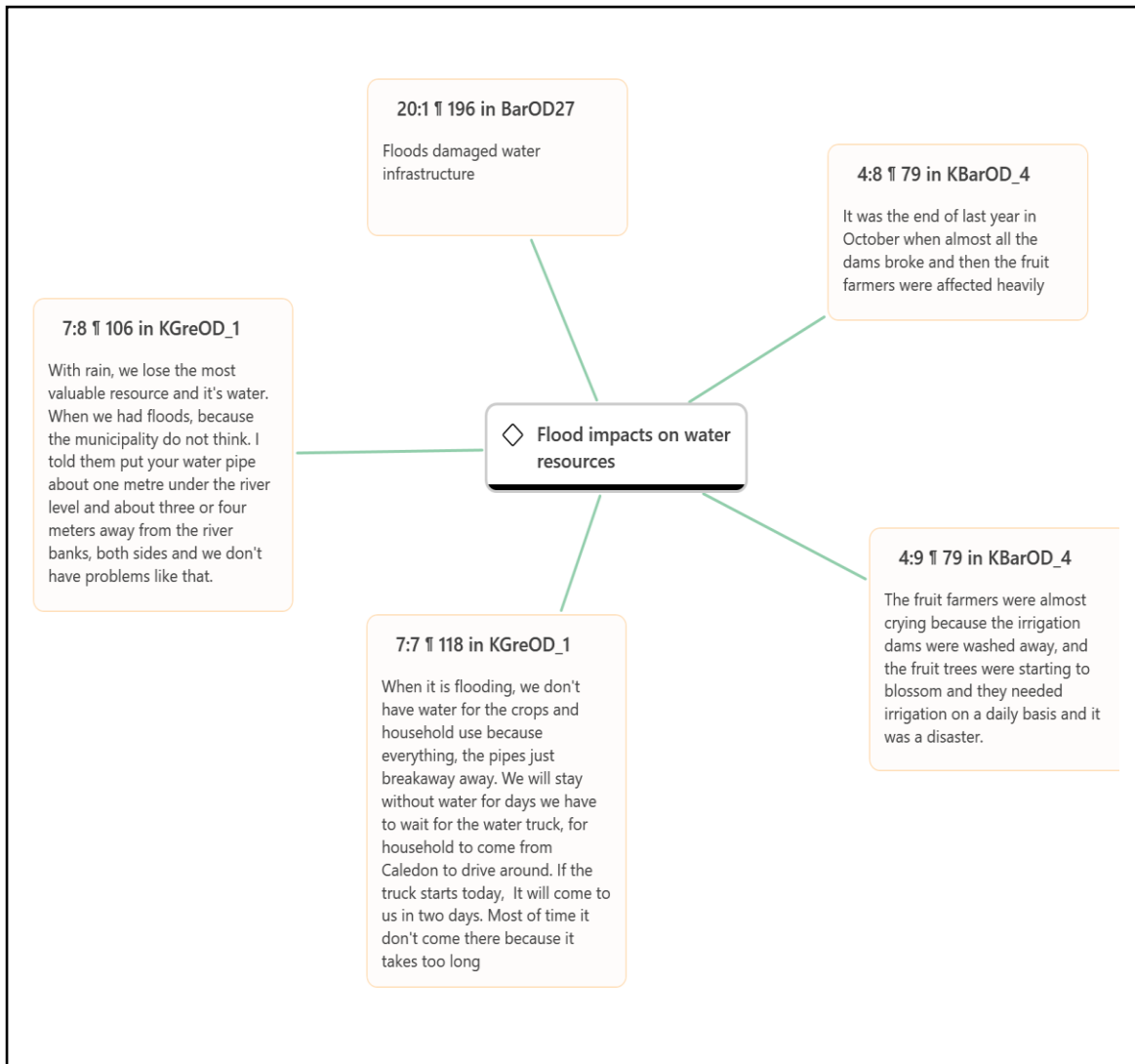


Figure 4.21: Impacts of floods on water resources from key informants

4.5 Climate change and drought effects on smallholder farming

4.5.1 Effects on the productivity of smallholder farmers

The participants were asked how the experienced droughts, floods, heat waves, storms, and forest fires influenced their farm productivity. Table 4.4 indicates the impacts of extreme weather events on smallholder farm production, as perceived by the participants. The effects of drought reported by the participants were a shortage of agricultural water (36%) and a reduction in crop yields (19%). Other impacts were a lack of grass (9%), death of livestock (6%) and low water quality (2%). A water shortage for irrigation during drought resulted in a reduction in crop yields. For example, participant **CaIOD11** said,

“Drought affects our yield because we run out of water for irrigation.”

Water shortage is among the primary factors limiting farm productivity in smallholdings (Sadiki & Ncube, 2020; Ncube, 2018). This was evident in this study, with participant **NapOD45** expressing:

“Crop yield decreased during drought.”

Another participant **BredOD48** indicated:

“Flowers die during drought.”

Water shortage appears to have had a huge effect on the agricultural productivity of smallholders. Hawkins et al. (2022) reported similar results in KwaZulu-Natal, where smallholder vegetable farmers experienced a reduction in yields during the drought period. Agricultural production among smallholders remains vulnerable to drought for several specific reasons, including a lack of adequate irrigation water, credit, farming resources and training, among other factors (Slayi et al., 2023; Bahta & Myeki, 2022; Ruwanza et al., 2022).

Another effect of drought on the productivity of smallholder farming was the death of livestock, which was associated with a lack of feed owing to dryness. This is evident in a statement by participant **BredOD49, from Bredasdorp**, who said:

“During the drought, it was dry, and there was a lack of feed for animals.”

The possible reason for the least impact of drought on livestock could be that most participants who were practising livestock farming were pig farmers, who do not require grazing pastures to get feed. The impact of drought on livestock production in smallholder farming coincides with the results of previous studies carried out in other provinces. Vetter et al. (2020) found similar results in KwaZulu-Natal, where smallholder livestock lost livestock during drought. In another finding, Bahta & Myeki (2022) determined that drought accounted for a 45% decline in cattle, 46% in sheep, and 48% in goats in the Northern Cape. This is similar to the findings of Maluleke and Mokwena (2017), who found that smallholder farmers in Giyani lost 709 livestock

owing to drought. However, in this study, there were fewer participants practising goat, cattle, or sheep farming, who may be more prone to the effects of drought on grazing.

Table 4.4 shows the major impacts of flood, loss of crops (24%), livestock mortality (17%), and damage to water infrastructure (9%). Other impacts included destroyed animal housing (7%), water pollution (4%), land degradation (4%), and damage to road infrastructure (3%). The participants experienced a series of floods that washed away crops. This is evident in participants' statements:

"We lost some crops because of the floods (BredOD29)."

"Floods destroyed our crops (BarOD26)."

"Floods prevented us from accessing our fields, washed away our grains, and caused damage to pastures (BredOD49)."

The effect of floods on crop production has been confirmed by a key informant who mentioned the following:

"We had about four major floods that resulted in the loss of crops. There is one farmer who lost about 30 hectares of butternuts. The butternuts went down the river because unnatural to have so much rain in five days (KGreyOD7)."

Critical infrastructure, such as roads, was severely damaged by floods, posing a challenge for farmers to access markets. During fieldwork, the effects of the floods were still visible on several roads used by farmers to reach the markets. Some roads were flooded, and several bridges were broken. Participant **BredOD48** said:

"The flood damaged the road, and we could not cross the river to go and sell our products because it was flooded."

Poor access to adequate infrastructure, such as proper roads, restricts smallholder farmers in South Africa from participating in formal markets (Manganyi et al., 2024). The occurrence of frequent floods is likely to aggravate the structural barriers.

The participants also expressed losing livestock during floods. Farmer **GenOD31** revealed losing 19 pigs. Similarly, during FGD, one farmer recounted losing 14

pregnant ewes that were due to give birth, which were swept away by flood. The participant said,

Last year, when it rained for almost a week, we lost quite a few of our ewes. We lost 14 ewes due to the river flooding during heavy (P5).

Although the participants built structures to keep their livestock, especially the pig farmers, floods damaged animal housing, causing substantial losses to farmers. Essential topsoil was washed away by flooding, forcing farmers to cultivate infertile soil. One respondent during an FGD in Caledon expressed the following:

“During the rainy season, we faced additional challenges with floods that destroyed our crops and washed away the crucial topsoil needed for farming. We have yet to recover the lost topsoil, and unfortunately, we cannot afford to purchase it, compelling us to cultivate on inferior soil that contains rocks (P6).”

The participants perceived an increase in extreme temperature as a contributing factor to crop failure (5%) and water shortage (3%). Elum et al. (2017) identified extremely hot weather conditions as a major factor hindering the productivity of smallholder vegetable farmers in three provinces, Limpopo, Mpumalanga, and Gauteng. High temperatures increase evaporation, leading to a reduction in surface moisture. Loss of soil moisture owing to excessive heat impacts irrigation demands, which could potentially strain water availability, especially in smallholder farming, where resources are limited. One farmer revealed during the FGD that they had to irrigate more owing to the strong heat. Mostafa et al. (2021) concluded that a rise in warming is likely to exacerbate irrigation demands and reduce crop production.

Other perceived impacts of climate change on farm productivity were the occurrence of forest fires and storms. However, forest fires were the least common among the respondents. The effect of fires on smallholder farming included the burning of pastures for grazing (4%) and the death of livestock (3%). The participants associated the occurrence of forest fires with excessive heat. Smallholder farmers usually rely on communal grazing rather than buying feed, owing to affordability issues. Therefore, the burning of natural pastures by forest fires diminishes feed for livestock, which could potentially lead to poor health for livestock and mortalities.

Another climate disaster was a storm which had similar impacts on farm production as floods (Table 4.4). Storms damaged crucial farming infrastructure (4%), caused crop damage (6%), and resulted in the death of livestock (5%). The occurrence of extreme climate disasters, including droughts, floods, heatwaves, forest fires, and storms, has harmed the productivity of smallholder farmers.

Table 4.4: Impact of climate disasters on smallholder farm productivity (N=100)

Climate Disaster	Impacts	Percentage
Drought	Water shortage	36
	Low crop yield	19
	Lack of grass	9
	Livestock mortality	6
	Reduced water quality	2
Flood	Loss of crops	24
	Livestock mortality	17
	Damage to water infrastructure	9
	Destroyed animal housing	7
	Damage to road infrastructure	3
	Water pollution	4
	Land degradation	4
Heatwave	Crops failure	5
	Water shortage	3
Forest fires	Loss of pastures	4
	Death of livestock	3
Storms	Crops loss	6
	Livestock mortality	5
	Damage to infrastructure	4

4.5.2 Impacts of climate change and drought on smallholder farmers' livelihood

Figure 4.22 presents the distribution of impacts on the livelihoods of the respondents. Okolie et al. (2023) argue that smallholder farmers risk losing their source of livelihood due to climate change. Farming was the primary livelihood strategy for the respondents. They relied on agricultural production as their livelihood since most of them did not have alternative sources of income. However, it was discovered that smallholder farmers abandoned cultivation (7%) mainly owing to water shortage during drought. This finding is evident in the participants' statements. such as:

"We stopped planting due to water shortages because we could not afford to hire a water truck (Farmer CalOD15)."

“We lost yield and stopped planting due to water shortages (Farmer CalOD14).”

“We experienced reduced yields and discontinued planting due to water shortages caused by excessively high temperatures and strong winds (Farmer CalOD11).”

“During the drought, we did not plant because there was no water, and livestock were drinking water from the municipality (Farmer GenOD18).”

Louis & Mathew (2020) observed similar challenges where climate change compelled smallholder farmers to stop planting owing to late rainfall and a repeated series of droughts. Okolie et al. (2023) reported similar results, with more than 50% of smallholder farmers interviewed having stopped farming owing to water scarcity caused by drought. Water shortage impacted the livelihood of farmers. It not only constrained farm productivity but also increased the cost of farm operations. The farmers were spending extra money on getting water from alternative sources and transporting it to the farms. This had the potential to reduce their business profits.

Maluleke et al. (2020) contended that rural livestock farming is no longer a “lucrative business” owing to the prevalence of harsh weather events and the financial implications of adaptation. In this study, one participant during the FGD highlighted that the number of individuals practising smallholder agriculture was declining owing to the increased risk of investing in farming amid harsh weather events. This simply means that the adverse effects of climate extremes are actively driving out smallholder farmers from their primary means of subsistence.

The case of farmers stopping farming owing to the effects of climate shocks was confirmed by key informants who, at the time of interviews, were agricultural advisors in the district with working experience of over 10 years. The key informant expressed that:

“Some of the farmers closed their farming businesses and faced a lot of liquidation issues because of the credit providers (Participant KBarOD9).”

“Livestock farmers sold their stock, and vegetable farmers stopped farming (Participant KCalOD5).”

Furthermore, the loss of livestock and low crop yields were perceived by the participants as the impact of a changing climate and drought, leading to a loss of income for smallholder farmers. However, most participants were unable to quantify their losses, especially on crops, even though they were aware of the potential income losses. During the FGD, one respondent revealed losing more than 60 pigs and piglets, of which a single pig was valued at a cost of R5000 by the farmer at the time of the interviews.

Loss of investment was identified by the participants who planted but did not get anything. One respondent during FGD recounted losing money on planting barley, but owing to drought, it did not grow to feed the livestock; instead, the farmer had to spend more money on buying feed. The increased cost of feed was another concern revealed by the participants during an FGD. The participants reported that the price of feed for livestock is high when it is dry.

Market prices constricted during drought. Livestock farmers had to sell their stock during drought to minimise losses. This was a challenge because they were selling out of desperation, which affected market prices. One respondent revealed during the FGD that, when the drought lasts longer, potential buyers take advantage of the crisis, want to buy livestock at low prices because they know farmers are desperate to sell.

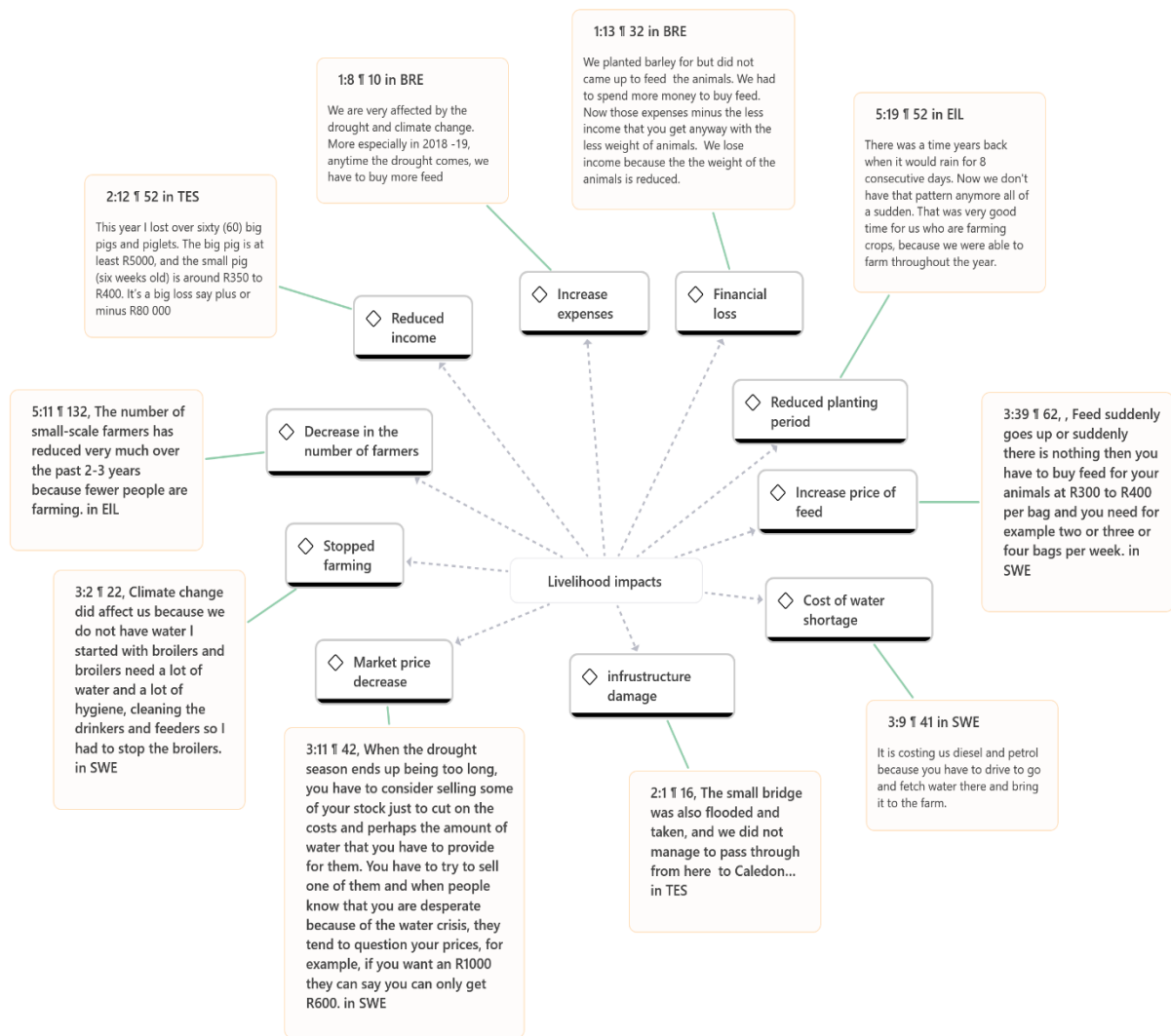


Figure 4.22: Distribution of impacts of climate change and drought on the livelihood of smallholder farmers

4.5.3 Impacts of climate change and drought on the well-being of farmers

Figure 4.22 summarises the impacts on the well-being of farmers interviewed in this study. The farmers were affected emotionally by the losses they endured on crops and livestock. Fanadzo et al. (2021), and Ubisi et al. (2017) found similar results. A feeling of worry, despair, and helplessness was observed in the participant’s responses:

“There is nothing I can do to stop the flood (Farmer GenOD77).”

“There is nothing we can do to stop the storm (Farmer GenOD30).”

“I am not aware of what to do (Farmer GenOD76).”

“The wind is too strong; even if you use a net, it won’t stop (Farmer GenOD21).”

“There is not much you can do because everything has to do with finances (Farmer GenOD35).”

The incidents of feeling distressed were confirmed by the participants during the FGDs (Figure 4.23). Other impacts on well-being were economic hardship, food insecurity, lack of portable water, and the physical strain of carrying water to the farms.

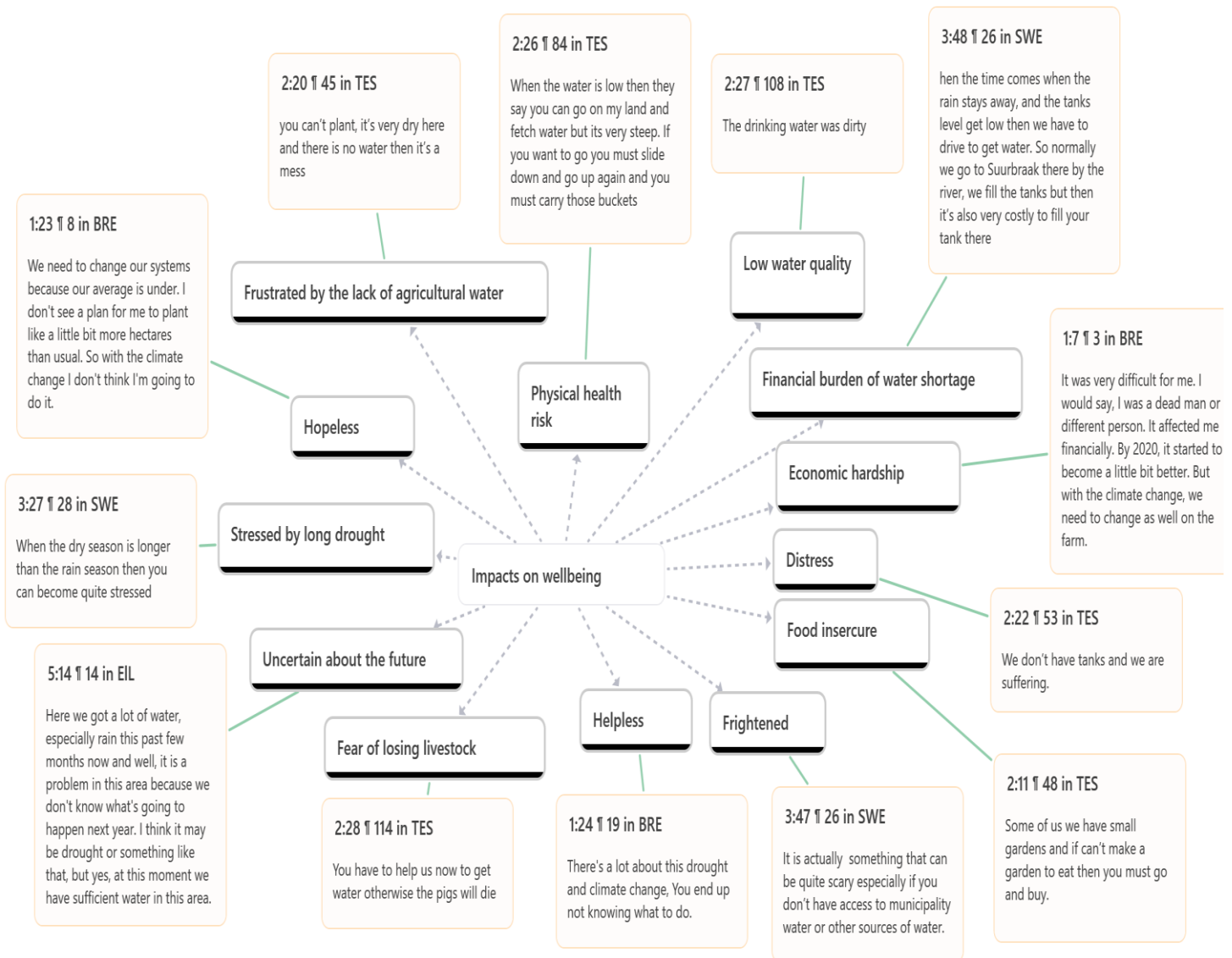


Figure 4.23: Distribution of impacts of climate change and drought on the well-being of smallholder farmers

4.6 Smallholder farmers' response to climate change and drought

4.6.1 Coping strategies

The study identified various coping measures deployed by farmers to manage the effects of weather extremes on farm productivity (Figure 4.24). During drought, most farmers transported water to farms (33%), relying on government relief (26%). This coincides with the results of studies conducted in the Western Cape recently. (Fanadzo et al., 2021; Pili & Ncube, 2022), which revealed that smallholder farmers transported water to the farms and received government relief assistance to cope with drought. Maluleke et al. (2020) reported similar results where smallholder livestock coped with the effects of climate change by purchasing water and receiving government relief aid, such as vaccines and feeds. Owing to resource limitations, smallholder farmers tend to rely on government relief, which often comes late when the damage has already been done, making it difficult for smallholders to recover losses.

Other strategies identified included storing water (9%) for dry periods, purchasing feeds (9%), selling livestock (5%) and limiting irrigation (5%). During floods, farmers had to relocate livestock (9%) to the mountains or high-lying areas. Coping strategies, such as limiting irrigation, were associated with a water shortage owing to drought, and buying feeds was a response to a decline in grass availability for livestock. Reducing the number of livestock to cope with the effects of climate change and/or drought was also reported in other regions locally, like KwaZulu-Natal, Limpopo, and the Northern Cape (Bahta & Myeki, 2022; Thinda et al., 2020; Mokwena & Maluleke, 2017). Two key informants confirmed that smallholder farmers were advised to downscale crop production and sell a portion of their livestock. During a FGD in Tesselaarsdal, one participant elaborated on this by expressing the following:

“My husband sold six pigs, and they were still small. He sold them because we were not able to feed them and give them water (FGP1).”

However, about 57% of farmers interviewed in this study indicated that they did not take any measures to cope with the climate. Similar findings were reported by Pili &

Ncube (2022), where the majority of farmers interviewed lacked strategies or only implemented a few.

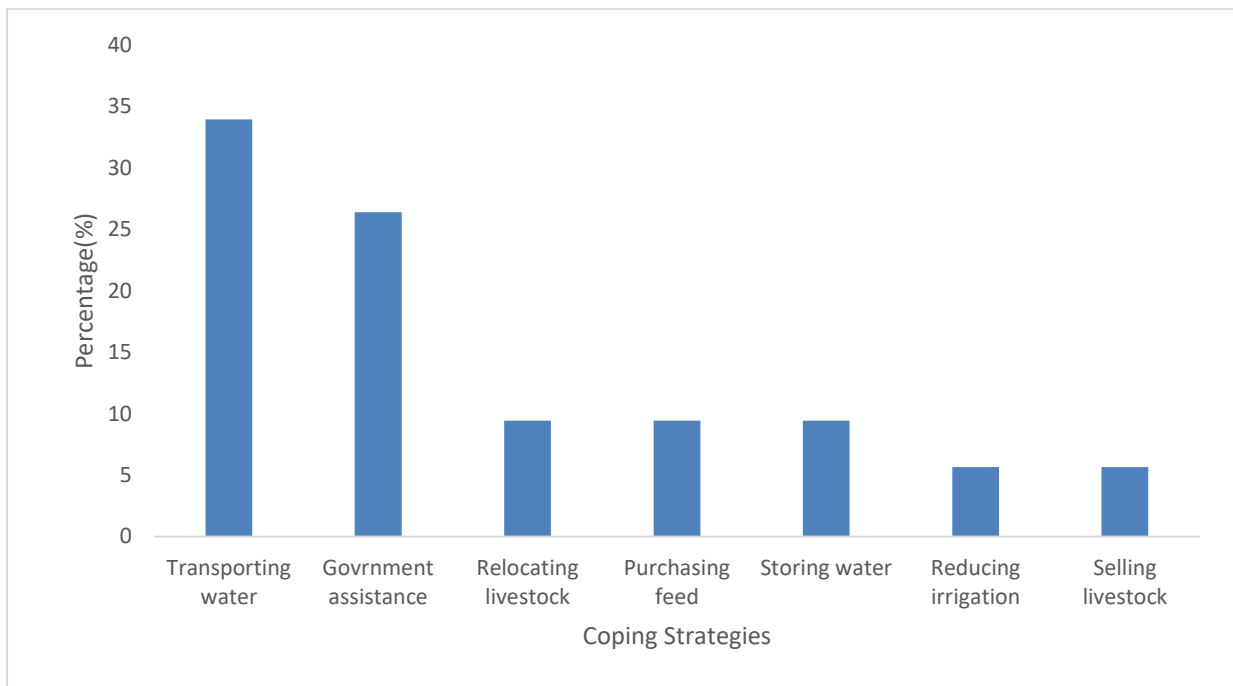


Figure 4.24: Distribution of coping strategies adopted by smallholder farmers (N=100)

4.6.2 Adaptation strategies

Figure 4.25 indicates that building shelters for livestock (18%), digging flood channels (18%), crop-shedding (16%), and creating fire breaks (14%) were commonly used adaptation strategies. The building of shelters was influenced by the persistence of floods that were killing livestock. Other reported strategies included using greywater (9%), rainwater harvesting (6%), taking insurance (6%), and buying tanks (6%). Mulching (3%) and composting were the least-used strategies (3%). Only 63% of the participants implemented strategies to deal with extreme weather conditions. This study is in agreement with previous studies, which reported a lack/low adaptation in smallholdings (Pili & Ncube, 2022; Mbuli et al., 2021; Omerkhil et al., 2020).

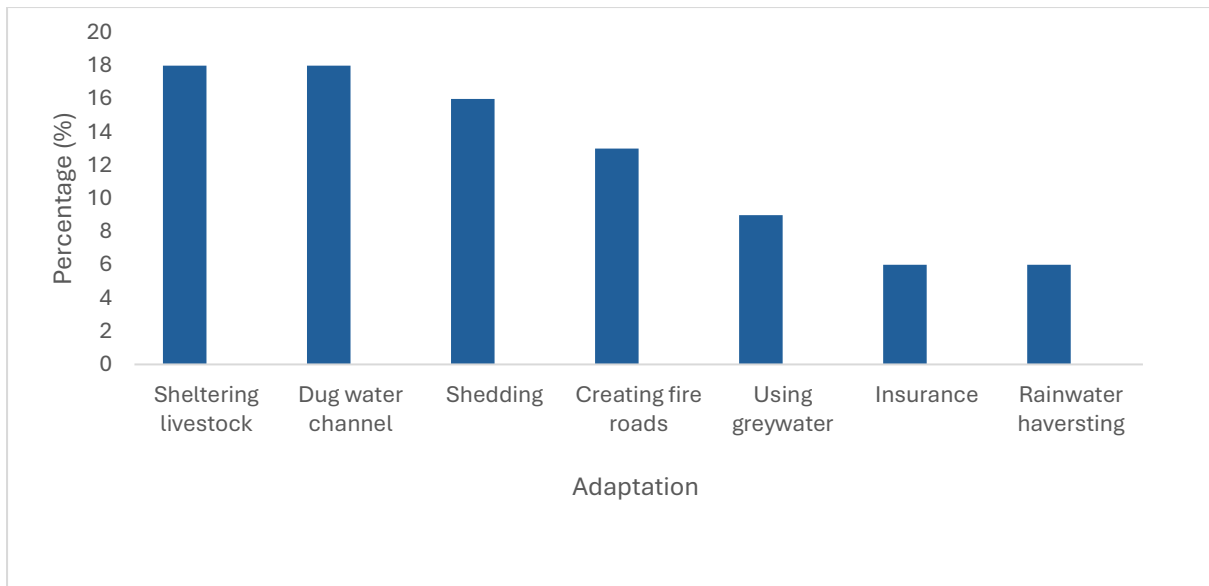


Figure 4.25: Distribution of adaptation strategies adopted by smallholder farmers (N=100)

4.6.3 Challenges faced in coping and adapting to the effects of climate change and drought

The identified barriers for coping and adaptation to climate change and drought were a lack of funding (40%), water shortage (22%), lack of support (17%), and resources (12%). Other challenges identified by the least number of respondents included inadequate farm size, lack of early warning systems, and insurance. These results are presented in Figure 4.26. About 22% of participants could not articulate the challenges they encountered when trying to manage the challenges posed by a changing climate and/or drought. Nkosi et al. (2023) reported among the constraints to adaptation for smallholder farmers in Mpumalanga were a lack of funds and adequate land sizes. Similar results were reported in Pakistan: financial constraints, water shortage, lack of support and limited farming resources hampered adaptation efforts to climate change for smallholdings (Shah et al., 2023). Likewise, Pickson & He (2021) reported a lack of access to agricultural water and inadequate land sizes as some of the barriers to adaptation among smallholder farmers in China.

Concerns were raised about a lack of access. During the FGD in Swellendam, farmers expanded on the challenges of financial capital as a major barrier to adaptation. The participants expressed the following sentiments:

“Climate change is happening, and perhaps it is happening faster than we thought. So, we have to adapt to times, but as small-scale farmers, in our case of being unemployed, we don’t have the financial means for adaptation (FGDP5).”

“It is expensive to put the right measures in place. We are small-scale farmers, and we do not have that financial capacity, so it is a bit of a challenge for us (FGDP3).”

A key informant later confirmed the challenge with accessing funding as a constraining factor to smallholder farmers’ climate adaptation.

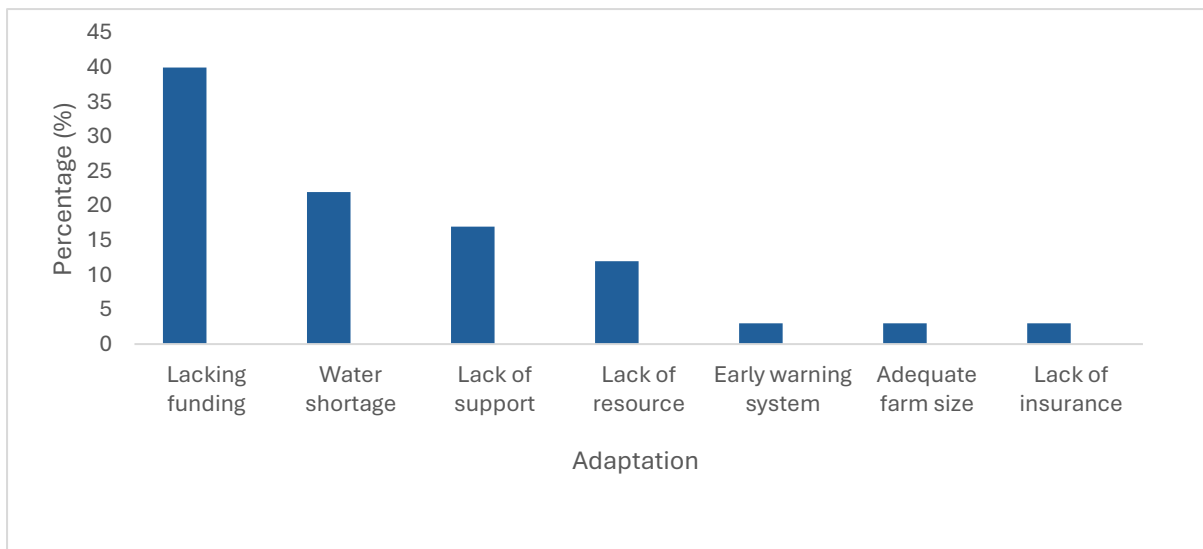


Figure 4.26: Perceived challenges to coping with climate disasters (N=100)

4.6.4 Perceptions of future adaptation

Most farmers lacked awareness of possible strategies to enhance their resilience to climate disasters. About 59 participants out of 100 reported that there is nothing they can do. This highlighted a lack of awareness of measures that farmers could use to adapt to future climate disasters. This finding resonates with the results of Nkosi et al. (2023), Pili and Ncube (2022), and Twecan et al. (2022), who uncovered that smallholders lack knowledge of adaptation strategies. However, the participants reported getting storage tanks, shade, drainage systems, boreholes, building dams, water conservation, changing planting dates, cultivating feed for livestock and building strong shelters as some of the strategies they are looking to implement in future. These

results are presented in Figure 4.27. Increasing water storage appears to be the most preferred strategy for addressing water shortage, especially during drought.

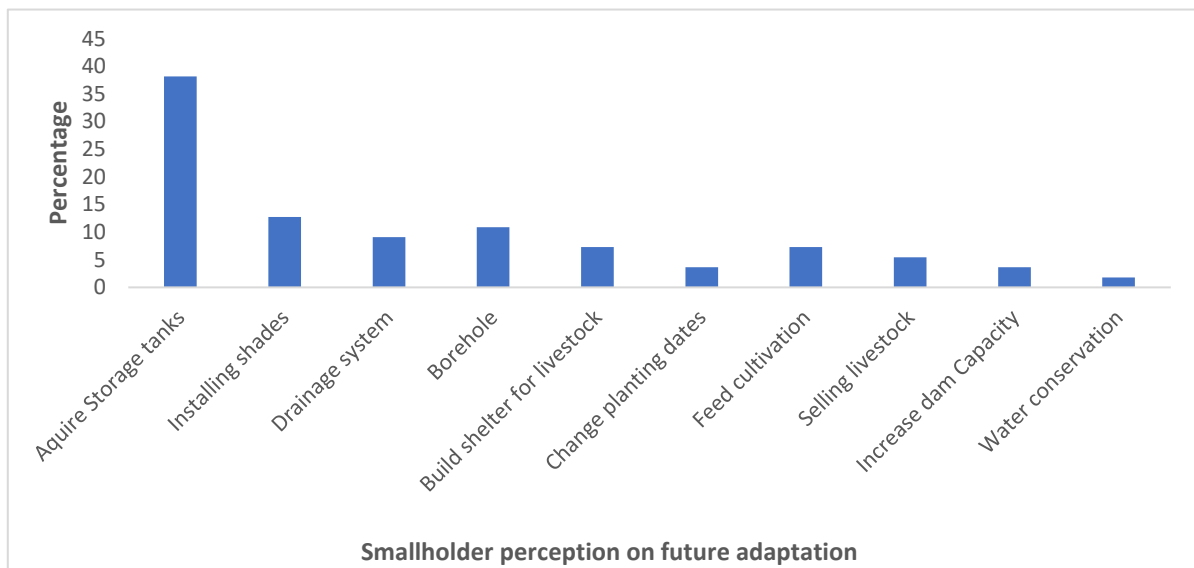


Figure 4.27: Smallholder farmers’ perceptions on future adaptation (N=100)

4.6.5 Institutional support

Smallholder farmers in South Africa have relatively few resources and usually rely on government support. The respondents were asked whether they received support from the government or any other institution to deal with the effects of climate disasters. The study found that 72% of the respondents reported no support, while 28% indicated that they received assistance from the government (Figure 4.28). Most participants did not get government assistance or support from any other institutions. This can be elaborated on by the participants’ statements:

“Only commercial farmers got support for the disaster (GenOD33)

We only filled out the forms, but they never came back to assist us (BredOD32).”

“The government only came to assess the damage and promised support, but the farmers have not yet received the support (BredOD49).”

Nonetheless, some participants received some form of support from the government, especially the Department of Agriculture. However, the challenge was the timing of the support because it did not always come at the right moment, especially when farmers

needed it the most during extreme climate disasters such as drought and floods. For example, farmer **SGenOD31**, when asked about institutional support for climate disasters, said:

“Not for the floods, but they did give me a water tank, pump, and feed. They also gave me equipment to make feeds, but did not support losses during the drought.”

This was a challenge for farmers because the relief assistance came after the disaster. Three key informants confirmed that there was a delay in supporting farmers during climate disasters. The key informants indicated:

“Funding takes time to reach the farmers. When funding reaches farmers long after the disaster, it has a limited effect on them (KBarOD9).”

“The drought declaration was late, and there was a late arrival of funds (KBredOD3).”

“The timeframe for disaster management was late to approve (CaIOD11)”.

This was similar to the results of Carelsen et al. (2023), who analysed institutional support of smallholder farmers during drought. These researchers highlighted that the government lacked proactive strategies for handling the disaster, which led to farmers receiving support very late. When disaster relief programmes arrive long after a disaster, their impact on the farm productivity of smallholders may be minimal or non-existent, simply because farmers might have lost so much on their crops and livestock production.

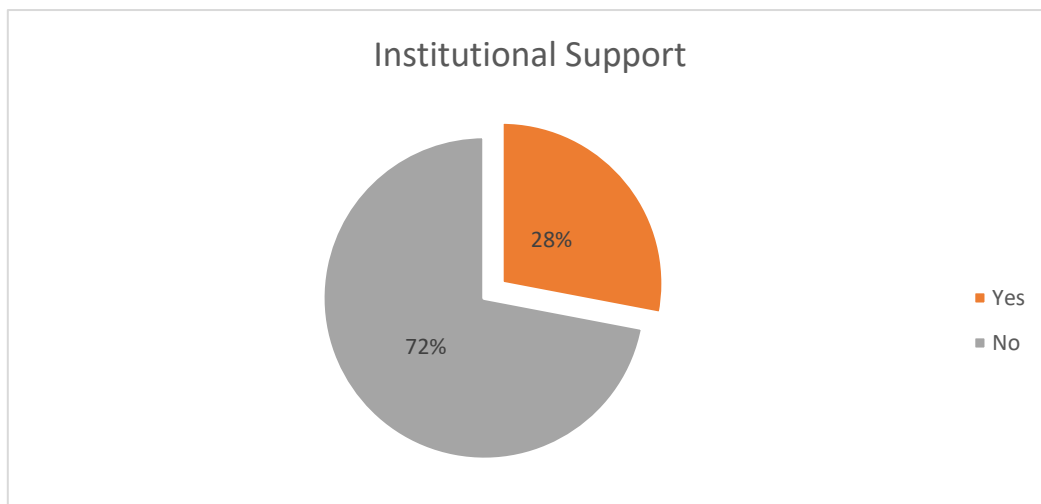


Figure 4.28: Smallholder farmers' perceptions of institutional support (N=100)

4.7 Other challenges for smallholder farmers

Figure 4.29 presents the distribution of other challenges encountered by the respondents. About 8% of the participants reported theft as one of the challenges they faced in their farming. In two FGDs, two participants reported that theft was prevalent and led to significant losses in agricultural production. Zantsi & Nkunjana (2021) highlighted that theft is a thorny issue in smallholder farming in South Africa. Installing tracking devices has been suggested as a solution to livestock theft (Zantsi & Nkunjana, 2021). In this study, the participants perceived a lack of fencing (5%) as a security risk that increased their vulnerability to theft.

Concerns about water-sharing conflicts were raised by the participants during the FGD in Tesslasdal. The participants reported that they get agricultural water that is flowing from the mountains down to the river, but a commercial farmer built a dam upstream, subsequently reducing water flow downstream. Another concern was that commercial farmers drilled a lot of boreholes, which led to a reduction in water availability. Farmers used various energy sources (petrol, diesel, electricity, and solar) to pump water for irrigation. One farmer reported that load shedding restricted irrigation. Load shedding, from a South African perspective, refers to the scheduled suspension of electricity supply by the national utility to prevent the energy demand from exceeding the generation capacity.

Other challenges were getting labour, old age, market access, alien invasive species, and support among farmers. One farmer stated that it was expensive to source hired labour. Another participant stated that it was difficult to expand farming due to old age. The reason for this could be that the farmer cannot afford to hire labour to take over the farming activities. Hence, during the FGD in Genadendal, farmers expressed the desire to transfer the skills to the youth so that they can take over agricultural activities in the future. Concerning market access, the main challenge was transportation to reach formalised markets. One farmer stated that the formal markets were far from areas where smallholders are operating. Manganyi et al. (2024), concurred that a lack of proper transportation restricts farmers from market access. During an FGD, one

farmer indicated that transportation was expensive owing to the cost of diesel and petrol.

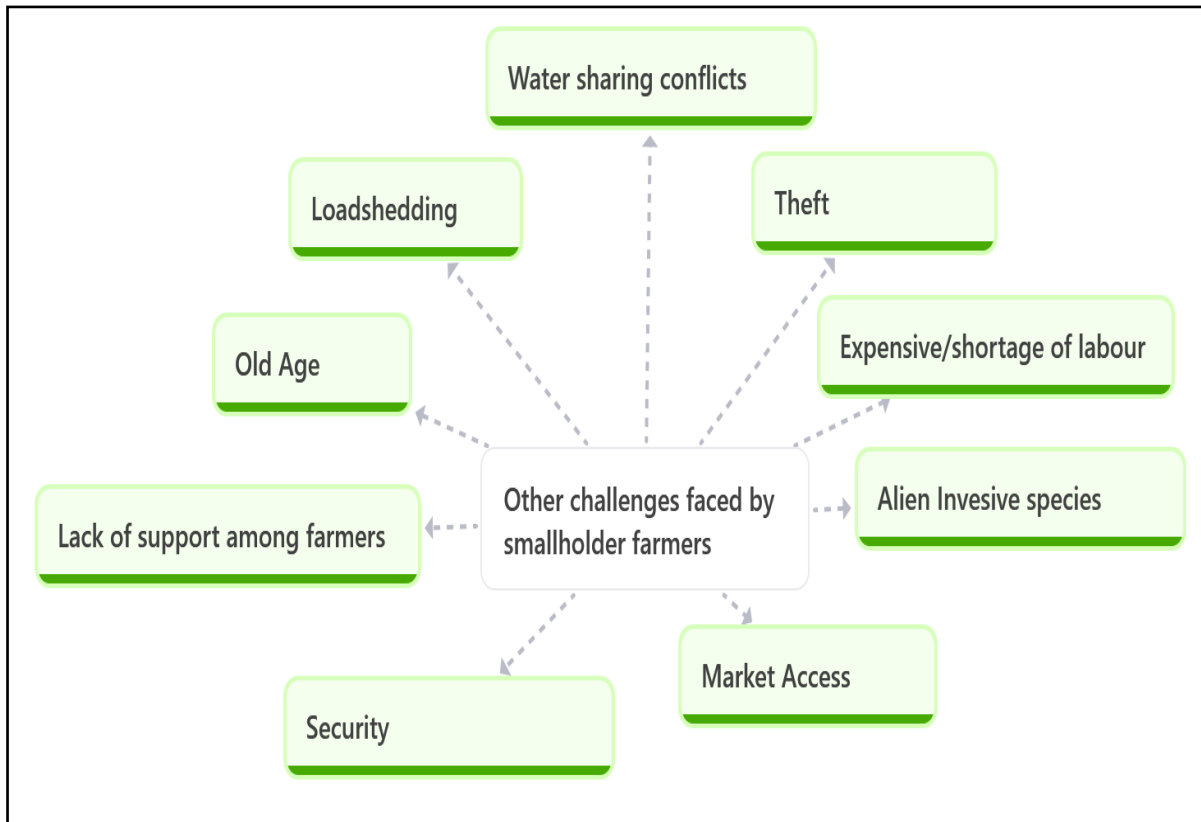


Figure 4.29: Distribution of other challenges faced by smallholder farmers

4.8 Support needed by farmers

Smallholder farmers need various supports to farm productively and build resilience to climate extremes. Figure 4.30 presents the type of support needed by the respondents. Concerning water shortage, respondents expressed the desire to receive assistance in acquiring water tanks (9%), boreholes (4%), building dams (4%) and training on water management (1%). Other support included funding (3%), farming equipment (10%), access to markets (2%), security fences (4%), agricultural land (8%), early warnings (1%), and irrigation systems (2%).

Some farmers cited training in business management (1%), farming skills (3%), pest management (1%) and natural resource management (1%), and adaptation (1%). The farmers also showed the desire to form smallholder farmers' associations (1%) and farm cooperatives (1%).

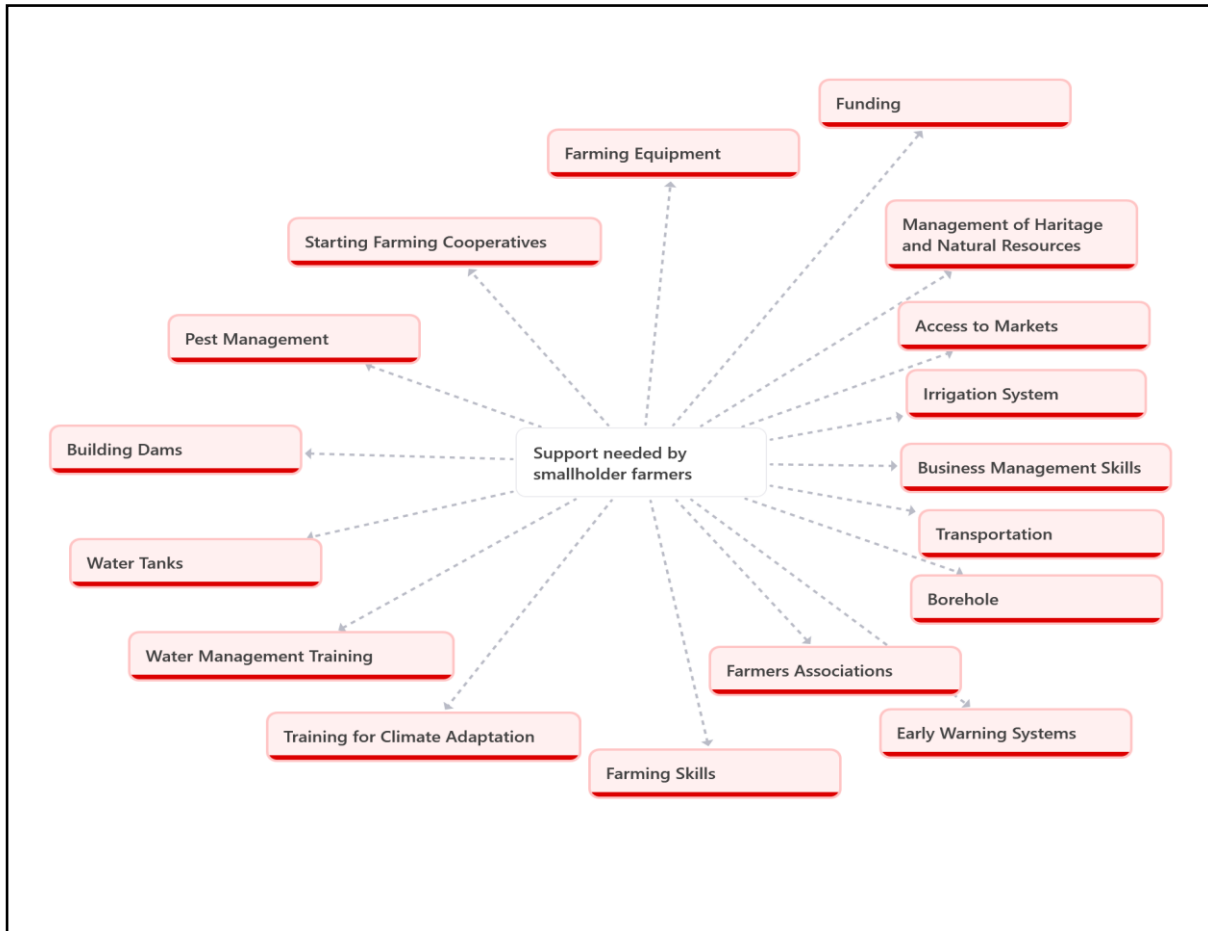


Figure 4.30: Various supports needed by smallholder farmers

4.9 Implications of the results for the livelihood capitals of smallholder farmers

4.9.1 Financial capital

The study showed that approximately 80% of smallholder farmers received their income from farming. Of them, 43% indicated that they were producing solely for markets, and 42% were selling a portion of their production to earn an income. However, most farmers expressed a decline in agricultural production mainly owing to water shortages and extreme weather conditions, resulting in reduced income. The farmers had financial capital, such as income or credit. Reduced income also had a bearing on the ability of farmers to have savings.

About 84% of farmers indicated having no access to credit facilities. Lack of credit or funding was a major concern for farmers wanting to expand production and invest in implementing measures to minimise the risks of climate variability on their farming. Lack of funding (40%) was a major factor restricting the adoption of effective adaptation measures, thus making the farming activities of smallholders more vulnerable to climate extremes. The farmers indicated that they need assistance with funding to build resilience to climate variability and farm productively.

4.9.2 Human capital

The study highlighted that few youths were engaged in farming, with just 9% representation. Farming was dominated by males, who were pensioners above the age of 60 years. Old age weakens the ability of farmers to sustain productivity, considering that they have limited resources to afford hired labour. Older farmers may not have the physical capacity for farming in future, which is typically intensive in smallholdings. One farmer expressed an inability to expand farming activities owing to age. Furthermore, the health of the farmers may deteriorate as they grow older, increasing their vulnerability to climate change and drought, as far as smallholder farm productivity is concerned.

The results revealed that most (58%) respondents were living in a household of four or more family members. Smallholder farmers usually rely on family labour. High household size could strengthen smallholder farmers' human capital by filling labour gaps that are needed for them to be productive. In terms of education, only 12% of farmers had tertiary qualifications. Low-level education may weaken smallholder farmers' human capabilities to adopt modernised farming practices and technology. However, the study revealed that 41% of respondents had farming experience of over 10 years, indicating extensive knowledge of farming. Farming knowledge could reduce the susceptibility of farmers to a changing climate.

4.9.3 Natural capital

The study showed the respondents could access different water sources, such as rivers, boreholes, dams, and rainwater harvesting. About 65% of the respondents reported a deterioration in water resources owing to the changing climate and

persistent drought conditions. Poor access to water and land resources constrained smallholder farm productivity. Abandoning farming activities owing to agricultural water shortage, mainly caused by drought, was reported by 7% of the respondents.

Access to adequate land size was a concern for the respondents. Half of the respondents reported that the land sizes were inadequate. The desire was expressed by farmers to acquire larger land sizes to expand farming activities. About 48% of the respondents were farming on a land size of less than a hectare. Only 24% of the respondents had land ownership. The other means of land access for farmers was renting, borrowing, and allocation by the local authority and, out of those, 39% did not have a lease agreement for land tenure security.

4.9.4 Social capital

Social networks, group membership, and cooperatives were limited. About 72% of the respondents were farming individually and did not have any group membership. The desire was expressed by the respondents to organise themselves into farming associations and cooperative enterprises in different settings. However, this was still at the formative stages and was discovered during the project workshop for future forecasting. Concerning group farming, 28% of respondents belonged to a cooperative. The strong presence of farmers' associations could increase the social capital of smallholder farmers.

4.9.5 Physical capital

The study discovered that the respondents experienced a series of floods that damaged basic infrastructure and tools needed for livelihood activities. The farmers indicated that floods washed away housing for pig farmers, road infrastructure, fencing, and water pipes. Farmers expressed that they could not access roads to market their products because of flooding that washed away water bridges.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The study investigated the impact of climate change and drought on water availability and the resultant effect on farm productivity, livelihood, and the well-being of smallholders to inform future adaptation strategies. The measures deployed by smallholder farmers to manage the effects of climate change and drought were identified, along with the factors limiting adaptation. The SLF was instrumental in guiding the study to analyse and understand smallholder farmers' adaptation to climate disasters.

The participants in this study perceived a shift in climate conditions as a rise in warming (68%), rainfall (51%), and exposure to harsh climate conditions, such as floods, drought, storms, forest fires, and heatwaves. Smallholder farmers faced challenges in accessing agricultural water, mainly owing to repeated droughts and a series of flood events. Water shortage reduced both crop and livestock production in smallholder farming. During drought, farmers experienced a shortage of agricultural water and dryness. Farmers reported stopped cultivation, lost crops, and livestock had died.

Floods caused severe damage to critical water infrastructure. Water supply for agricultural production in smallholder farms was interrupted by floods that washed away dams and smallholder irrigation systems. Floods destroyed, reduced water quality, washed away crops, and killed livestock. Exposure to heightened temperatures diminished water resources, leading to crop failure. Storms and forest fires were other extreme events that constrained farm productivity, shown by reported cases of losing crops, pastures, and livestock.

Farming was an important means of livelihood for smallholder farmers interviewed in this study. It contributed to household food and income generation. The findings showed that smallholder farmers were losing income from the death of livestock and declining crop production. This meant smallholder farmers were at risk of losing their vital source of livelihood. Adverse weather conditions increased the cost of farming when farmers spent more money on feed and agricultural water. Cases were reported of farmers abandoning farming during droughts. It was discovered that the number of

farmers was declining. Investing in farming amid climate variability was perceived as a high risk for smallholder farmers. Market prices constricted during drought, compelling smallholder farmers to sell their stock at lower prices.

The impacts of extreme weather conditions on smallholder farm productivity took an emotional toll on smallholder farmers. Farmers were worried about their future in light of the changing climate. The farmers who were losing production showed a feeling of distress and loss of hope because of the struggle to implement effective strategies to minimise the impact of climate disasters on crops and livestock production. The respondents had a lower capacity to withstand the effects of extreme weather conditions. The majority of farmers did not implement any strategy, citing a lack of resources, a lack of funding, water shortage, inadequate land, and insufficient institutional support. However, most farmers lacked knowledge of strategies that they could implement to enhance their capacity to withstand the vagaries of climate variability. This was evident in their responses, when they indicated that they did “not know what to do” or that “there was nothing [they] could do”. This finding highlights a lack of training in climate adaptation among farmers in smallholder agriculture. It may also mean that the occurrence of the droughts or floods was devastating, such that even with measures in place, these measures were inadequate. Hence, enhanced adaptation is required. Smallholder farmers require continuous training to build capacity for future adaptation.

Water shortage was a huge problem for the production of smallholder farmers. The farmers outlined several strategies that they are looking to implement in future to adapt to water shortage. This included the purchase of water tanks, drilling boreholes, building dams, and adapting to water-saving farming techniques. Other adaptation strategies that farmers are willing to implement in future to bolster their productivity include installing shade for crops, changing planting dates, cultivating feed for livestock and building strong structures to house livestock. Nonetheless, the smallholder farmers need support in funding and technical expertise to implement some of these strategies.

Smallholder farmers in this study relied on government support to be productive, even though 72% of the respondents indicated a lack of institutional support to cope with climate disasters. Farmers reported receiving some form of support from the

Department of Agriculture. The challenge with government relief programmes for climate-related disasters, such as drought, was that it took a long time to reach the smallholder farmers. This was confirmed by a key informant who stated that the declaration of relief programmes for drought takes longer, resulting in farmers receiving support late or when the disaster has long passed. By that time, farmers would have lost so much in their production, and the relief would have little or no impact. Therefore, the government should consider incorporating technologies that use remotely sensed data for early drought and flood detection to speed up the process of disaster declaration before it causes damage.

Smallholder farmers experienced additional challenges in their farming. Among the challenges was theft. During the FGDs, farmers expressed concern that farm theft was on the rise. Farmers reported losing their crops and livestock owing to theft. This could constrain the development of smallholder farmers if left unabated. Other concerns included poor market access and water-sharing conflicts.

5.2 Recommendations

The study revealed the dominance of old male farmers over female farmers. The challenge of having few females participate in farming is that it perpetuates gender inequality in farming. Increasing access to land and funding can increase women's participation in agriculture. The minimal involvement of youth in farming raises future concerns about the sustainability of the sector. Having programmes that focus on training and funding youth to pursue careers in agriculture could increase their participation in farming. Youth participation in farming could be increased by having targeted funding and training for agricultural programs.

Farmers expressed the desire to acquire bigger plots to expand their farming activities. About 50% of the respondents reported that their land was inadequate. The municipality should help smallholder farmers access land and give them long-term leasing contracts. About 31% of the respondents did not have lease agreements. These farmers did not have secure land tenure and might be discouraged from investing in long-term agricultural production.

In terms of access to credit, only 16% of the respondents reported having access. The respondents identified land ownership as a major barrier to credit access. Therefore, it is necessary to address the systemic barriers to land ownership. Farmers' access to credit is key to the economic development of smallholding agriculture. Smallholder farmers need credit to improve farm practices, such as the procurement of technology.

The smallholder farmers were vulnerable to the effects of extreme weather conditions. They had limited access to natural, human, physical and financial capital assets. They often relied on government support to sustain their livelihood. While smallholder farmers received different forms of assistance from key local institutions, there is a need to accelerate this support into building dams and boreholes to improve water availability and access in smallholder agriculture. The focus should shift from providing relief to developing smallholder farming systems that are climate resilient through capacity building.

The impact of extreme climate events on water availability and the resultant effect on smallholder farm productivity was intensified by limited capacity for adaptation. Most smallholder farmers reported not implementing strategies for coping and adaptation. They were not aware of strategies that they could implement to reduce the impact of climate extremes. Efforts should be directed to awareness raising on climate adaptation among smallholder farmers. Key stakeholders working with smallholder farmers should invest in education for climate adaptation in smallholder farming systems.

Water productivity in smallholder agriculture could also be improved by training farmers to produce more crops with less water. This includes using water for irrigation efficiently to improve productivity and build resilience to climate change and drought. The findings of the study have implications for government policies. Therefore, it is recommended that the government invest in building and maintaining small irrigation schemes in smallholder farming to enhance adaptation to climate change and drought. The government should also consider establishing a climate adaptation fund with a strong focus on smallholder farmers to help them acquire the latest technology and resources for climate adaptation.

5.3 Future research

Youth participation is lacking in smallholder farming. Future studies should consider focusing on examining strategies that could foster youth participation in smallholder agriculture to reduce poverty and unemployment. The limitation on the knowledge of climate adaptation in smallholder farming is a concern. Future research should analyse the level of awareness of climate adaptation in smallholding to strengthen adaptive capacity.

Smallholder farmers are not a uniform group. They are diverse individuals with different access to capital assets and institutional contexts. Therefore, future studies should analyse the effects of climate change in smallholder agriculture, considering individual context to provide specific information for future adaptation. Finally, other studies may focus on quantifying the losses of smallholders owing to extreme weather conditions to provide data that could be used for formulating policies.

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APPENDICES

Appendix I: Consent form



Water Research Commission Project: C2022/2023-00845

Water governance, institutions, and infrastructure integration for climate-resilient pathways for smallholder farming systems in the Western Cape, South Africa

Consent Form

Interview/Focus Group Number..... Date.....

This is to confirm that you agree to participate in a focus group discussion/interview in relation to the project, *Water governance, institutions, and infrastructure integration for climate-resilient pathways for smallholder farming systems in the Western Cape, South Africa*. You confirm that you understand the project objectives as explained by the researchers.

Please be assured that the information you provide will only be used for research purposes. Your name will not be included in any report and the information will be treated with confidentiality. The discussion may require about 45 minutes of your time. Please be advised that to allow the researchers to capture everything that you say during this discussion, and to give quality time to follow the discussion, a recording device will be used. If there is any information that you are not comfortable providing during the discussion, you are free to remain silent. If, at any point, you feel that you no longer want to continue with the discussion, you may excuse yourself.

If agreeable to the conditions of the study, please sign in the space below.

Yours sincerely

Prof Bongani Ncube
Email: ncubeb@cput.ac.za, Tel: 021 959 6111

I willingly give my consent to participate in the interview/focus group discussion under the conditions provided above.

Name: _____ **Signature:** _____

Date: _____

SARCHI Chair in Governance and Economics of Water and Sanitation Sector Institutions

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<http://www.cput.ac.za/>



Livestock:

.....
.....

A.6 Is your land enough for your farming activities? Yes No

A.7 Are you farming as a group or individual?

.....

A.9 What do you do with the farming products that you produce from your farming?

Mainly for sale

Mainly for family consumption

Mainly for family consumption and sell excess Other (please specify):

A.10 Do you have access to any credit providers? Yes No

A.11 If yes in **A.10**, which of the following organisations provide credit to you? (Select all that apply)

Co-operative		Land Bank	
Commercial Bank		Other (Please specify)	
Blended Finance			

SECTION B: AGRICULTURAL WATER RESOURCES

B.1 What sources of water do you use for farming?

Tick box – e.g. dryland, irrigation, stock watering, borehole, river, canal, water scheme

.....
.....

B.2 Do you have a water use license or water use rights? Yes No - check

If **no**, please explain

.....
.....

B.3 Do you pay any fees for using water for farming?

Yes No

B.4 If yes in **B.3**, how much do you pay for water use annually?

.....

B.5 If yes in **B.3**, are you able to pay for the water that you need for your farming? Yes No

B.6 Have you ever experienced water shortages for farming from your sources in the past 20 years? Yes No

If yes, please explain

.....
.....

SECTION C: CLIMATE CHANGE AND DROUGHT

E.1 What is your understanding of climate change?

.....
.....

What is your understanding of drought?

E.2 What do you think are the causes of climate change?

.....
.....

E.2 What do you think are the causes of climate change?

E.3 Where do you get the information about climate change in your area? (Select all that apply)

Farmers Union		Family/friends	
Radio		Social media	
Newspaper		Extension services	
TV		Internet	
Workers		Other	

E.4 What changes in temperature and rainfall did you observe in the past 20 years? (Select all that apply)

The temperature has Increased		Increased rainfall	
The temperature has decreased		Decreased rainfall	
No change in temperature		No change in rainfall	
Not aware		Not aware	

Do you measure rainfall or temperature?

E.5 What extreme weather events have you experienced in the past 20 years? (Select all that apply)

Droughts	
Floods	
Heatwaves	
Forest fires	
Storms	
Other please explain	

E.6 What were the effects of extreme weather events you have selected in **E.5** on crops, livestock and water for agriculture?

Crops:

.....

Livestock:

.....

Water for agriculture:

.....

E.7 What measures have you taken to reduce the effects of extreme weather events you have selected in **E.5**?

.....

E.8 Did you get any support from the government or other organisations to reduce the effects of extreme weather events you have selected in **E.5**? Yes No

E.9 If yes in **E.8**, please explain

.....

E.10 How did you cope with the extreme weather event you have selected in **E.5**?

.....

E.11 What challenges did you face in coping with the effects of extreme weather events you have selected in **E.5**?

.....

E.12 What strategies are you most likely to employ to respond to the effects of extreme weather events in future?

.....

E.13 Is there anything else you would like to add?

.....

Thank you for your time!

Appendix III: FGD Interview Guide

Focus Group Discussion Guide for Smallholder Farmers

1. Introduction

- a. Welcome
- b. Overview of the topic
- c. Ground rules

2. Questions

- a. How did changing rainfall and temperature patterns affect water availability?
- b. How did the changes in rainfall and temperature affect your crop yields and livestock production?
- c. How did it affect your income and means of livelihood?
- d. What measures have you put in place to respond to water shortages?
- e. What support did you receive to cope and adapt to water shortages?
- f. What are the organisations you work with in managing water?
- g. What is your involvement in decision-making in these organisations?
- h. What strategies do you think should be employed to deal with the impacts of water shortages?

Appendix IV: Key Informant Interview Guide

PARTICIPANT NO.

DISTRICT:

TOWN:

DATE OF INTERVIEW:

FACILITATOR:

OBJECTIVE: To assess the performance of water infrastructure, water governance and institutional arrangements, as well as to derive climate adaptation pathways for smallholder farmers in selected historical settlements in the Western Cape province of South Africa

PROFILE OF RESPONDENTS

Name of institution/organisation:

Profession:

Age range:

Years of experience:

A: AGRICULTURAL WATER RESOURCES

What sources of water do smallholder farmers use for farming?

How do you support smallholder farmers accessing water?

How do you measure temperature and rainfall (climate change)?

Do smallholder farmers pay any fees for using the water for farming?

What support do you give to those smallholder farmers who are not able to pay water use fees?

B: CLIMATE CHANGE AND DROUGHT

What climate-related disasters have been experienced in your area in the past 20 years?

How do you communicate information about climate-related disasters to smallholder farmers?

What were the effects of those climate-related disasters on water resources?

How did the impacts of climate-related disasters on water resources affect smallholder farmers?

What measures have you taken to help smallholder farmers to cope with the impacts of climate-related disasters?

What challenges did you face in trying to reduce the impacts of climate-related disasters on smallholder farmers?

What strategies are you most likely to employ in reducing the impacts of climate-related disasters on smallholder farmers in the future?

Appendix V: Ethical clearance letter



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Ethics Approval Letter

Reference no: 230444121/11/2023

Office of the Chairperson Research Ethics Committee	Faculty of Applied Sciences
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On 6 November, 2023, the Faculty Research Ethics Committee of the Faculty of Applied Sciences granted ethics for the below project at the Cape Peninsula University of Technology.

Title of project:	Impacts of climate change and drought on smallholder farm productivity in the Overberg District Municipality, South Africa
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Comments (Add any further comments deemed necessary, e.g. permission required)

1. Humans are involved in the study.
2. This permission is granted for the duration of the study.
3. Research activities are restricted to those detailed in the research proposal.
4. The research team must comply with conditions outlined in AppSci/ASFREC/2015/1.1 v1, CODE OF ETHICS, ETHICAL VALUES AND GUIDELINES FOR RESEARCHERS.

	9-11- 2023
Prof Sjirk Geerts Chairperson: Research Ethics Committee	Date