ANALYSIS OFTHE PROFITABILITY OF CONSERVATION AGRICULTURE FOR PARTICIPATING SMALLHOLDER MAIZE FARMERS IN THE VHEMBE DISTRICT OF LIMPOPO PROVINCE.

By

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DECLARATION

I, Rudzani Grace Mulaudzi, hereby declare this thesis titled **- Analysis of the Profitability of Conservation Agriculture for Participating Smallholder Maize Farmers in the Vhembe District of Limpopo Province** - for Doctor of Philosophy in Rural Development (AGRPPRD), submitted to the Institute for Rural Development at the University of Venda has not been previously submitted for any degree at this or another university. It is original in design and execution, and all reference materials have been duly acknowledged.

Signature __________________________ 29/08/2025

MULAUDZI R.G **Date**

DEDICATION

This work is dedicated to, my late mother Mrs Thifulufheli Emmah, my late brother Mashudu Godfrey, my daughter Vhutshilo, my son Khuthalani and my granddaughter Murendeni.

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ABSTRACT

Sustainable increase in maize yield for smallholder farmers demand complementary technologies and supporting policies. In South Africa, the adoption efforts for conservation agriculture have been done without a consideration of the economic viability of maize production for smallholder farmers. This study aims to analyze the profitability of conservation agriculture for participating smallholder maize farmers in Vhembe District of Limpopo Province. This study used probability sampling and simple random sampling to sample 337 smallholder maize farmers from four Vhembe District local municipalities. Research design was mixed-method approach used to solicit data from sampled smallholder maize farmers. The objectives were to characterize smallholder maize farmers, to investigate factors and perceptions influencing the adoption of CA among smallholder farmers, to assess the economic viability of CA and lastly to propose a framework for sustainable agricultural practices. Descriptive results indicates that majority of the respondents were female (53.71%), majority of the participants (66,.77%) were aged above 51 years of age, majority (76%) of the participants adopted CA partially while the most adopted CA principle was crop rotation (24.03%) and only more than half (51.04%) did not have access to extension service and only 24.03% practiced crop rotation whereas only 17.51% of them have received full training on CA. Training could be associated with knowledge and therefore, lack of full training can explain partial adoption of CA by smallholder maize farmers in Vhembe District. Cross-tabulation results revealed that factors like age (p=0.001), knowledge (p=0.001) and training (p=0.036) influenced the adoption of CA. OLR findings emphasize that training effect had 2.17 times higher odds (95% CI:1.12-4.20) of being in higher adoption category (partial/full vs. non, or full vs. partial/non) and again, knowledge gradient posed a strong dose-response relationship: each knowledge level increase substantially raises the odds of adoption. The assessment of gross margins over the five-year period indicated a fluctuating pattern, where in years 1 (R21 537.85), 3 (R23 054.65), and 5 (R42 316.76) showcased a consistent upward trend in gross margins whereas year 2 (R20 573.70) and year 4 (R22 658.58) revealed a decrease of gross margin. On ranking production inputs, fertilizer (R861.13) costs shows to be the main contributor while mulching costs was the lowest (R489.45). Both semi-log and double log models revealed that inputs variable remained highly significant (p<0.001) affirming its role as a strong predictor of profit. Moreover, AOV indicated that no-tillage variable significantly correlates with economic profitability, showing farmers not practicing no tillage with a mean yield of 4.15 (on the log scale), thus a higher yield compared to those who were practicing no tillage (mean=3.89). The assessment of gross margins over five years reveals insightful trends, highlighting the critical role of fertilizers and no-tillage practices in shaping economic profitability. The disparities observed across different years emphasize the need for flexible and adaptive farming strategies. Collaboration of key agricultural role players and needs-oriented CA support can play a vital role in the provision of inputs and targeted support to address inputs and CA compatible implements for sustainable and economic viable CA.

Key words: Conservation Agriculture, Smallholder Farmers, economic viability and economic profitability.

Table of Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

CCRP	Climate Change Response Policy
CAADP	Comprehensive African Agricultural Development Program
CA	Conservation Agriculture
CARA	Conservation Agriculture Regulation Act
DAAF	Department of Agriculture, Forestry and Fisheries
DOIT	Diffusion of Innovation Theory
EU	European Union
FAO	Food and Agriculture Organization
IDP	Integrated Development Plan
IFAD	International Fund for Agricultural Development
NDP	National Development Plan
NEPAD	New Partnership for Africa's Development
NGOs	Non-Governmental Organizations
SA	South Africa
STATSSA	Statistics South Africa
SSA	Sub-Sahara Africa
SDGs	Sustainable Development Goals
UN	United Nations
USA	United States of America
VDM	Vhembe District Municipality
WB	World Bank

CHAPTER 1 INTRODUCTION

1.1 Background of the Study

The global high prevalence of low agricultural yield and the growing population are exacerbating concerns over the resilience of current food production systems. A study in South Africa (Misselhorn *et al.,* 2017) reported that food insecurity has been a concern for decades and raised debates on the methods and technologies of sustainable food production; these findings were also confirmed in a study conducted in KwaZulu Natal (KZN) by (Hlahla, 2018) as well as Bhaga *et al.,* (2020) in Sub-Sahara Africa. The United Nations (UN) declared - to end hunger, achieve food security, improve nutrition and promote sustainable agriculture by 2030 - as one of the seventeen Sustainable Development Goals-SDGs (United Nations, 2015; Mugambiwa and Tirivangasi*,* 2017; Liborde *et al*., 2020). One of the UN's strategies for achieving the aforesaid goals was through doubling the agricultural productivity and income for smallholder farmers, hence, sustainable agricultural methods may assist in realizing this SDG (National Development Plan-NDP, 2011; Statistics South Africa-STATSSA, 2019).

According to a report from Brazil (Kassam *et al.*, 2018) Conservation Agriculture (CA) can be a game-changer to the challenges faced in the agricultural production systems. This was based on the evidence from South and North America (1930s), then from Brazil (1970s). Conservation Agriculture was used by these countries, as well as the European Union and Asians as an approach to address environmental problems, such as climate variability, water and soil threats (Kassam *et al.,* 2018). Prior studies in the USA (Francaviglia *et al*., 2023; Kassam *et al*., 2022 and Xiao *et al*., 2021) noted that the concept of CA encompasses the practical application of three interlinked principles, namely: no or minimum mechanical soil disturbance (no-tillage), biomass mulch soil cover (using residues to cover crops) and crop species diversification (crop rotation).

According to Kassam *et al.,*(2018) CA works best in conjunction with other complementary good agricultural practices of integrated crop and production management. Since 1990s, researchers and international development organization like Food and Agriculture Organizations (FAO), International Fund for Agriculture Development (IFAD), World Bank (WB) have advocated for CA as a climate-smart agricultural technology, meant to build food security which is vulnerable to climate variability (droughts, floods, heat waves, water shortage) (FAO, 2019; Kihara *et al*., 2020). There has been a growing concern that as nations accelerate food-security resilience systems, farming practices should also respect the environment. The African continent cannot be exempted from conserving the environment, especially with the dominance of rural smallholder farmers who are mostly dependent on rain-fed agriculture to sustain their income and livelihoods.

African leaders under the New Partnership for Africa's Development Agreement (NEPAD) swore that they also have a pressing duty to eradicate poverty and to place their countries on a path of sustainable development growth (United Nations, 2001). Conservation agriculture also received a spotlight as an approach to manage agroecosystems for improved and sustained productivity, increased profits and food security. Swanepoel, (2018) reported that CA practitioners in African countries, significantly improved food security.

In Mozambique, CA was promoted with other cropping management practices such as timely weeding. Conservation agriculture, however, was found to be insignificant on Malawi and Zimbabwe's food security, due to the problem that they failed to implement fully the complements of practices necessary to set off the biophysical process expected to drive yield increase (Mango *et al*., 2017). Conservation Agriculture has been advocated as having marked potential benefits - increased yield, energy savings, soil erosion control and water-use efficiency. Despite advocacy for CA, smallholder maize farmers in sub-Sahara Africa have been slow to adopt its principles, South Africa included (Brown *et al*., 2019; Steward *et al*., 2019 and Bouwman *et al*., 2021).

According to STATSSA (2019), South Africa (SA) is a middle-income country which is food secure at the national level, however, the experience of food insecurity and malnutrition at the household and individual levels are immense. Issues of household food and nutrition insecurity have led to worldwide concerns recently, as the impact of climate variability and threatening economic conditions are putting extra stress on food production systems.

The National Development Plan (NDP) sees agriculture as the primary economic activity in the rural areas. Moreover, the agricultural sector is perceived to have the potential of creating 1 million jobs in the country by 2030 (NDP, 2011 and Vhembe Integrated Development Plan (Vhembe IDP), 2018/19). Furthermore, several global studies (Bunderson *et al*., 2017; Muzangwa *et al*., 2017; Tambo & Mockshell, 2018; Kassam *et al.,* 2018) have recommended

CA as a strategy to enhance soil health, increase crop yields and food security, while reducing input costs. In KZN, Ntshangase *et al*., (2018) reported that farmers' perception about CA positively correlated with higher maize yields. Moreover, the Department of Agriculture Forestry and Fisheries-DAFF (2016) maintains that in 2008/9, approximately 5.2million hectares of farmland was cultivated, with 368000 hectares (7%) under conservation agriculture. Different findings and reports suggest that there is hope for enhancement of maize production under CA practices.

According to Maponya, (2021), Vhembe District (VD) is well-known for agricultural opportunities and the place is dominated by smallholder farmers with different agricultural commodities such as grain, vegetables and fruits. However, smallholder farmers are prone to barriers inhibiting sustainable agricultural production. Several studies have been conducted in Vhembe District concerning smallholder farmers' vulnerability to climate shocks and natural resource mismanagement (Ofoegbu *et al.,* 2018; Senyolo *et al*., (2018) and Zikhali *et al*., (2020); nevertheless, none of these studies have assessed the impact of conservation agriculture on the livelihoods of participating smallholder maize farmers. Conservation agriculture practices may enhance maize production, thereby, sustaining the livelihoods of the participants.

1.2 Problem Statement

Regardless of maize (*Zea mays*) being a staple crop and a significant source of income for millions of smallholder farmers, unsustainable agricultural systems in many regions have led to soil degradation, low productivity, and increased vulnerability to climate shocks (Bedeke *et al*., 2020; Grote *et al*., 2021 and Mutengwa *et al*., 2023). Countless agricultural efforts and technical expertise have been directed at eradicating food insecurity (Balila *et al*., 2020 and Nhemachena *et al*.,2020). Maize production in SSA is expected to increase by three-folds to adequately feed the projected growing population of about 2 billion by 2050 (Falcon *et al*., 2022 and Van Dijk *et al*., 2021). In response, CA has been promoted as a sustainable alternative that can improve soil health, boost farm productivity, and ultimately enhance the livelihoods of smallholder farmers (Canton, 2021 and Kassam *et al*., 2019). Nevertheless, empirical evidence on the socioeconomic impacts and economic viability of maize production under CA remains fragmented and region-specific (Akinnifesi *et al*., 2018; Moyo *et al*., 2021). While several studies documented the environmental benefit of CA (Tambo *et al*., 2018; Kassam *et al*., 2019; Page *et al*., 2020 and Feuntes *et al*., 2021). In Vhembe District there is no research that simultaneously (a) profiles smallholder maize farmers adopting these practices, (b) explains the key socioeconomic factor (such as farm size, access to credit, education level, and support from extension services) that influence a farmer's decision to adopt CA on maize farming, and (c) evaluates whether CA-based maize production offers an economically viable pathway for smallholder maize farmers. These gaps are critical given the need to understand how sustainable practices translate into tangible improvements in livelihoods and farm profitability, especially in the context of evolving smallholder farmers' conditions and climate risks.

1.3 Research Questions

(i) What are the characteristics of smallholder maize farmers practicing conservation agriculture in the Vhembe District?
(ii) What are the factors and perceptions which influence the adoption of conservation agriculture practices by smallholder maize farmers in the Vhembe District?

(iii) Is smallholder maize farming under conservation agriculture economically viable?

(iv) What could be the best framework for sustainable conservation agriculture practices which can increase maize yield and enhance smallholder farmers' livelihoods in the Vhembe District?

1.4 Research objectives

The main objective of this study was to assess the adoption of conservation agriculture and its impact on livelihoods of participating smallholder maize farmers in the Vhembe District.

The following were specific objectives for this study which are to:

(i) Characterize smallholder maize farmers practicing conservation agriculture in the Vhembe District,
(ii) Investigate the factors and perceptions influencing the adoption of conservation agriculture practices by smallholder maize farmers in the Vhembe District,
(iii) Assess the economic viability of maize production for smallholder maize farmers who adopted conservation agriculture in the Vhembe District,

(iv) Provide a framework for sustainable conservation agriculture practices, for increased maize yield and enhanced the livelihoods of smallholder farmers in the Vhembe District.

1.5 Justification for the Study

The sustainability of livelihood for smallholder farmers depends on the enhancement of food production, especially, staple crops like maize production (Adu *et al*., 2018; Jeleta *et al*., 2018 and Bedeke *et al*., 2020). However, the success of maize production rests with sustainable agricultural technologies. Conservation agriculture has been proposed as the most appropriate remedy to the re-curing economic and climatic challenges hampering smallholder maize farming (Brown *et al*., 2019 and Steward *et al*., 2019). However, the challenge remains with the practical application of CA, (Ntshangase *et al*., 2018 and Brown *et al*., 2019). While the environmental benefits of CA such as enhanced soil fertility and reduced erosion have been well documented (Tambo *et al*., 2018; Kassam *et al*., 2019; and Fuentes-Llanillo *et al*., 2020), there is still a gap in knowing the economic benefits of CA and also understanding the socioeconomic dimensions related to its adoption. Characterizing the socioeconomic characteristics, understanding factors which influence CA adoption and assessing the economic viability of maize production under CA may be a holistic analysis critical in identifying potential constraints and opportunities for effective policy intervention. This study was significant because closed the empirical gap by supporting the practice of sustainable maize farming with both economic and environmental benefits for sustainable livelihoods of smallholder maize farmers.

1.6 Definition of key terms

6.1.1 Conservation Agriculture

Conservation Agriculture (CA) is a global term, however, there is no universal definition which results in no uniformity of its application. This was emphasized by Hobbs., (2007), Carmona *et al*., (2015); and Kassam *et al*., (2017b) who stated that there are uncertainties about CA and the lack of systematic reporting schemes, due to inconsistencies in the term's definition. FAO (2014a) defined "conservation agriculture" as an approach to managing agroecosystems for improved and sustained productivity, increased profits and food security while preserving and enhancing the resource base and the environment. Strauss *et al*., (2021) note the term

CA as a holistic farming system aimed at the conservation of natural resources by - halting soil erosion and increasing biodiversity in cropping systems, while still effecting sustainable production.

Conservation agriculture is widely acknowledged as a set of management principles that support soil conservation (Govaerts *et al*., 2009; Smith *et al*., 2017; Kassam *et al*., 2019). Conservation agriculture is loosely defined among South African farmers, industry experts and academia as any action that has soil-conservation goals, however, this vagueness has created root confusion and may lead to misperceptions of conservation agriculture as simply a sustainable crop-production system (Kassam *et al.,* 2019). Swanepoel *et al.,* (2021) further indicated that in South Africa, the term "conservation agriculture" is often used to describe any soil conservation action rather than a combination of the three management principles that the concept encompasses, namely, minimum soil disturbance, using a diversity of crops in rotation or association, and protecting the soil with an organic soil cover.

There are some commonalities in the above definitions, however, the confusion surrounding CA definition persists; although for the purpose of this study, the definition proposed by FAO (2014a) will be adopted. This study will follow the definition of conservation agriculture which states that it is an approach to managing agroecosystems for improved and sustained productivity, increased profits and food security while preserving and enhancing the resource base and the environment (FAO, 2014a). This definition is suitable for this study because it entails the management of agroecosystem which in this case is the soil, water, weather and human efforts, which is the production environment for smallholder farmers.

1.6.2 Smallholder farmers

Morton (2007), notes that there is no universally accepted definition of "smallholder farmers", thus, the term has been defined differently from country to country. In USA, for example it is defined as farmers - cultivating small areas of land (usually less than 10ha, often about 2ha), use family labor, and depends on their farms as their main source of both food security and income generation (Cornish, 1998 and Nagavets, 2005). In SSA, smallholder farmers are defined as farmers - with small landholdings and the associated characteristics include dependence mostly on household labor for production and low use of technology. Smallholder farmers are also defined as farmers with low asset base and operating in less than two hectares of cropland (World Bank, 2011; Gebremed and Jaleta, 2010). Although smallholder farming means different things to a vast number of researchers, there has been some consensus. According to Chayanov (1986), the key feature of the agricultural smallholder sector is its dependence on household labor, hence, linking the operations of the farm to the family's consumption, labor circumstances and demographic cycles.

Basically, the definitions characterize smallholder farms as - (a) small farms, (b) family-operated, (c) no or limited non-family hired labor (World Bank, 2007). Smallholder farmers in SA has been explained by Machethe *et al.*, (2004) as, black farmers most of whom reside in the former homelands. It is also noted that not every black farmer is a smallholder farmer and smallholder farmers are not a homogenous group, however, according to IFAD (2011), there is less agreement on whether other factors ought to be included in the definition. The most important of which (for both analytical and for policy and even political purposes) is the ability of the household or family to sustain its livelihood based on its self-employment on its own farm. Most of the above definitions are size based. This study, however, adopted the definition by Cornish (1998) and Nagavets (2005) which state that smallholder farmers are individuals who mostly cultivated small areas of land (usually less than 10ha, often just 2ha), use family labor, and depend on their farms as their main source of both food security and income generation. Similarly, smallholder farmers in the Vhembe District, are farming on more than one hectare land, use family or hired labor and depend on their farms as their main source of both food security and the sustainability of their livelihoods.

1.6.3 Livelihoods

According to Chambers and Conway (1991) livelihood is the people's capacity to maintain a living. The authors add, "A livelihood comprises the capabilities, assets (stores, resources, claims and access) and activities required for a means of living; a livelihood is sustainable, which can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation; and which contributes net benefits to other livelihoods at the local and global levels and in the long-term".

Also in SA, there are no clear definitions of livelihoods, however, most studies dwell on "sustainable livelihoods", nevertheless, Guo and Kapucu., (2018) indicated that livelihoods are not only the circulation of various resources, commonly labeled as forms of "capital", but also how social roles are constituted and power circulated. This research will adopt the definition by Chambers and Conway (1992) that livelihood, "comprises the capabilities, assets (both material and social resources) and activities required for a means of living" and that a livelihood is sustainable when it can cope with and recover from, maintain or enhance its capabilities and assets, while not undermining the natural resource base; it entails increased profits and food security. We cannot talk of enhanced livelihood if the households are still food insecure, and lastly, it focuses on preserving and enhancing the resource base and the environment (hampered by climate variability) which smallholder depends on (rain fed environment) for their livelihood.

1.6.4 Agricultural technology adoption

Eveland (1979) explains that adoption is "making full use of a new idea as the best course of action available". Noting that there is no clear definition of "adoption" in South Africa, this study will use a dictionary definition which states that adoption is the act of accepting, embracing, or starting to use something, as an idea, behaviour, characteristics or principles (Dictionary.com). In smallholder farming, adoption of agricultural technology specifically refers to the ways in which farmers implement new technologies into their farming practices. This process can encompass a wide range of innovations, from genetic modifications and new crop varieties to advanced data analytics and precision agriculture tools. Agricultural technology is increasingly seen as essential for enhancing efficiency, increasing productivity, and promoting sustainability within the agricultural sector (https://en.wikipedia.org/wiki/Adoption).

1.7 Organization of the thesis

This thesis is organized into seven chapters as follows: chapter 1 (Introduction), chapter 2 (Literature review), chapter 3 (Methodology), chapter 4 (report on characterization of smallholder farmers), chapter 5 (report on factors influencing the adoption of CA), chapter 6 (report on the economic viability of CA) and chapter 7 presents summary, conclusion, recommendations, suggested framework and areas for further study.

CHAPTER 2

LITERATURE REVIEW

2.0 Chapter introduction

In this chapter, CA literature was dissected into theoretical, methodological and empirical perspective of CA. The following literature was also explored to give insight on CA, that is, the characteristics of smallholder farmers; the context of sustainable livelihoods; the cruciality of maize production and the impact of climate variability on smallholder farming. The reviewed literature was drawn from different published prior studies, such as journals, articles and books.

2.1 Theoretical perspective of CA

The theoretical perspective underpinning CA is entrenched in sustainable development and resource management theories. Conservation agriculture is increasingly perceived as a promising solution to the numerous challenges faced by smallholder farmers in Sub-Saharan Africa. The region is highly vulnerable to the impacts of climate change, such as erratic rainfall and prolonged droughts, which severely affect agricultural productivity (Ngoma *et al*., 2021 and Corbeels *et al*.,2020). According to (Kassam *et al*., 2019), sustainable agricultural practices does not only enhance agricultural productivity but also improve the socio-economic conditions of farmers. As a result, smallholder maize farmers explore CA as an alternative agricultural practice to increase resilience and productivity. Conservation agriculture, with its focus on minimizing soil disturbance, maintaining soil cover, and practicing crop rotation, has proven to be an effective strategy for improving soil fertility and enhancing productivity, even under challenging environmental conditions (Kassam *et al*., 2019; Tambo *et al*., 2019, and Fuentes-Llanello *et al*., 2020). Sustainable farming techniques have the potential to improve the livelihoods of smallholder maize farmers in a rapidly changing agricultural landscape.

Conservation Agriculture is characterized by three interlinked principles, along with other complementary good agricultural practices of crop and production management, namely: (1) Continuous or minimal mechanical soil disturbance (no-tillage) ,this principle is implemented by the practice of no-till seeding or broadcasting of crop seeds, and direct placing of planting material into untilled soil, thereby, causing minimum soil disturbance from any cultural operation, harvest operation or farm traffic (Kassam *et al.,* 2018; Bunderson *et al.,* 2017); (2) maintenance of a permanent biomass soil mulch cover on the ground surface (mulching), this principle is implemented by retaining crop biomass, root stocks and stubbles and cover crops and other sources of ex-situ biomass (Kassam *et al.,* 2018; Bunderson *et al.,* 2017) and (3) diversification of crop species/ crop rotation, this principle is implemented by adopting a cropping system with crops in rotations, and/or sequences and/or associations involving annuals and perennial crops, including a balanced mix of legume and non-legume crops. (Kassam *et al.,* 2018; Bunderson *et al.,* 2017). Bunderson *et al.,* (2017) posit that the message from CA is "make small planting holes with a dibble stick or hoe (mimic the old age practice of planting across Africa before the introduction of ridging), retain crop residues produce in-situ and diversify crops with rotations and or intercrops". Kassam *et al.,* (2017) reiterated that if the three principles are applied separately, they do not constitute a CA system, for example, the use of no-till practice on its own does not qualify the production system to be CA based, unless it is linked to the application of the other two practices of soil mulch cover and diversified cropping.

This study is underpinned by Diffusion of Innovation Theory (DOIT) by Rogers (2018). Diffusion of Innovation Theory has been adopted in several agricultural innovation studies (Strong *et al*., 2022; Sood *et al*., 2022 and Munguia *et al*., 2021). This theory rests on five attributions - (1) relative advantage in comparison to existing technologies; (2) compatibility with the organization workflows and knowledge; (3) complexity to implement; (4) trialability, and (5) observability of the development of the innovation, both inside the organization and in competitors. Theories of behaviour and innovation adoption like Rogers' Diffusion of Innovations highlights the essence of awareness, perceived benefits, and socio-cultural factors in the adoption process (Rogers, 2018).

The theoretical perspective of CA for smallholder maize farmers revealed a deeper understanding of its potential environmental benefits and challenges. Sustainable development theories seek to amplify productivity while also promoting environmental sustainability and enlightening the livelihoods of the participants. The application of Roger's Diffusion of Innovation emphasizes the importance of socio-cultural dynamics, knowledge transfer and perceived benefits in persuading adoption of CA. Moreover, the incorporation of institutional support theories emphasizes the role of policy frameworks in enabling the widespread of CA practices.

2.2 Methodological perspective of CA

Descriptive studies such as Nyambo *et al*., (2019) reported that characterization of smallholder farmers has been conducted in various research using diversity of methodologies, for example, the use of machine learning algorithms, participatory and expert-based methods. All approaches used end up with the development of some subgroups known as farm typologies for smallholder farmers practicing CA. Characterization of smallholder farming systems refers to describing the various categories of farms, their demographics, attributes, production trends, and existing production systems. Wijk *et al*., (2018) reported different land size for smallholder farmers from country to country, for example, 50% of smallholder farmers in Rwanda farm in a 0.3ha land while more than 75% of smallholder farms are smaller than 2ha (a common threshold to describe smallholder farms).

Myeni *et al*., 2019 reported that SAPs such as intercropping, mulching and crop rotation were more likely to be adopted by farmers with access to land yet without access to credit (and had low levels of education, although this finding was not significant). In contrast, new SAPs such as cover cropping, minimum tillage, tied ridging and planting pits were more knowledge (education), capital and labour intensive. Again, descriptive analysis conducted by Abegunde *et al*., 2019 found that off-farm income and distance of farm homestead were statistically significant but negatively correlated with the level of adoption. Several descriptive studies on adoption often considered socio-economic characteristics and overlooked economic factors influencing farmers' behavioural intention towards adoption of technology.

Moreover, quantitative studies such as those conducted by Asfaw *et al*., (2020), utilize surveys and regression analyses to quantify the relationship between CA adoption and various livelihood indicators, such as income and food security. Qualitative research, including case studies and focus group discussions (e.g., by Krampe *et al*., 2022), provides deeper insights into farmers' experiences and perceptions regarding CA. Moreover, Lee and Gambiza (2022) used scoping review to assess the barriers and enablers of CA for smallholder farmers in Southern African Development Community (SADC), a qualitative content analysis was performed. Mixed-methods approaches have emerged as an effective way to triangulate data, allowing for a comprehensive understanding of both the qualitative and quantitative aspects of CA adoption (Nyanga *et al*., 2023; Chinseu *et al*., 2018; Mugandani and Mafongonya., 2018). Mixed-metho approach is a valuable research type as it capitalizes on the strength of both qualitative and quantitative research (Nagpal *et al*., 2021).

2.3 Empirical perspective of CA

Empirical studies provide significant indication on the impact of CA on smallholder maize farmers' livelihoods. Research indicates that the adoption of CA practices, such as minimum tillage and crop rotation, leads to improved soil health, increased yields, and enhanced resilience against climate change (Dixon *et al*., 2022; Hyman et al., 2024). For instance, a study conducted in Zambia showed that smallholder farmers practicing CA reported a 30% increase in maize yields compared to traditional farming methods (Manda *et al*., 2019). Furthermore, the adoption of CA has been linked to improved social capital, as farmers often collaborate through local groups to share resources and knowledge (Sengunda *et al*., 2021). However, barriers such as limited access to inputs, knowledge gaps, and economic constraints continue to impede wider adoption among smallholder farmers (Shumba *et al*., 2023).

2.3.1 Characteristics of smallholder farmers in Sub-Saharan Africa (SSA)

Smallholder farmers in Vhembe District, SA, face numerous challenges, including climate variability, limited resources, and soil degradation, which affect their agricultural productivity and livelihoods (Vhembe Agricultural Development Strategy, 2024). The age and experience of smallholder farmers are determinants for the adoption of new agricultural technologies, including conservation agriculture. Older farmers, who have extensive farming experience, often tend to rely on traditional farming methods passed down through generations. These older farmers may be hesitant to adopt new practices, particularly those that require a shift in mindset or the use of new technology (Ma and Wang, 2022; and Foguesatto, 2022). This resistance to change is often due to a lack of awareness of the benefits of other farming strategies, such as conservation agriculture and the perceived benefits of switching from familiar farming practices to new ones.

On the other hand, younger farmers, especially those who have received formal education, tend to be more open to adopting innovative farming practices. According to Davkota *et al.* (2022) and Yang *et al.,* (2022) younger, better-educated farmers are generally more willing to experiment with conservation agriculture practices because they understand the long-term benefits, such as improved soil fertility and better yield stability. This demographic group is more likely to view conservation agriculture not only as a tool for increasing productivity but also as a method for mitigating the risks posed by climate variability.

Concerning education for smallholder farmers, it plays a crucial role in the adoption of any strategy, like Conservation Agriculture. In regions like SSA, where literacy rates and formal education may vary significantly, education becomes a barrier or an enabler for agricultural innovation. Farmers with higher levels of education are better equipped to understand the principles behind conservation agriculture practices, such as minimal tillage, crop rotation, and mulching, which are essential for improving soil health and boosting productivity (Supbamzer *et al.*, 2021 and Ruzannte *et al.*, 2021).

Farmers with access to agricultural training programs and extension services are also more likely to adopt conservation agriculture, as they receive the necessary technical education, support and resources to implement these practices (Musarifi *et al*., 2022 and Oyetunde-Usman *et al*., 2021). In many parts of Africa, including Southern Africa, the availability of agricultural extension services has been linked to the successful adoption of conservation agriculture (Foguesatto *et al*., 2020 and Belachaew *et al*., 2020). These services provide farmers with practical knowledge on how to improve crop yield while preserving the environment.

The access to resources, such as land, capital, and inputs like seeds and fertilizers, is a significant factor influencing the adoption of conservation agriculture among smallholder farmers. In SSA, many smallholder farmers face challenges related to land access. With high levels of land fragmentation and unclear land tenure systems, farmers may be reluctant to invest in long-term conservation practices that require secure land rights (Tai, 2023). In the Vhembe District, where land is often divided among multiple family members, smallholder farmers may struggle to implement conservation agriculture practices effectively (Sebola and Mamabolo, 2020).

In addition, limited access to capital and credit further exacerbates the challenges of adopting conservation agriculture (Peneiro *et al*., 2020). The initial costs associated with purchasing inputs, such as no-till equipment, mulch, or cover crops, can be prohibitive for resource-poor farmers. In a study by Raimi *et al.,* (2021), it was shown that the lack of financial support and affordable credit schemes often prevent smallholder farmers from investing in the technologies necessary for practicing conservation agriculture.

Moreover, the socio-economic context and support system in which smallholder farmers operate impact the farming system. In many rural areas of SSA, farmers depend on subsistence farming and have limited access to markets, making it difficult for them to generate enough income to reinvest in their farms (Aggrawal *et al*., 2024 and Stringer *et al*., 2020). This limited economic capacity often leads to a focus on short-term survival rather than long-term sustainability, making farmers hesitant to adopt technologies like conservation agriculture that require initial investments.

Government policies and institutional frameworks also play a significant role in shaping agricultural production. In regions where governments provide subsidies for sustainable farming practices, such as conservation agriculture, farmers are more likely to engage with these practices, however, in the absence of supportive policies, farmers may be less motivated to adopt new techniques (Edwards, 2020). As noted by Siebretch (2020), the lack of consistent government support, particularly in remote areas, is a significant barrier to the adoption of new technologies in SSA.

2.3.2 The context of sustainability of livelihoods in South Africa

The livelihood framework emphasizes the complex interplay between economic, social, and environmental factors that affect rural households, particularly smallholder farmers (Yin *et al*., 2020 and Zhao, 2021). In South Africa, the rural economy is predominantly based on agriculture, and smallholder farmers rely heavily on this sector for both food security and income. According to Kuang *et al*., (2020), these farmers are not only dependent on farming for sustenance but also for their social well-being, as farming contributes to the overall socio-economic stability of rural households. The rural agricultural sector, however, faces numerous challenges, including limited access to essential resources such as land, water, and finance, which impede the farmers' ability to improve their livelihoods and achieve sustainable production (Gowda *et al*., 2018 and Zerssa *et al*., 2021).

One of the major issues faced by smallholder farmers in rural SA is the limited access to productive resources (Das *et al*.,2022; Pawlak *et al.,*2020 and Autro *et al.,* 2021). Land tenure systems, for example, can restrict smallholder farmers from accessing or expanding their farms, leading to inefficiencies in production. In many cases, land is either communally owned or subject to complex legal frameworks, which makes it difficult for farmers to make long-term investments or improvements on the land. According to a study by Viana *et al*., (2022), lack of secure land tenure has been one of the major constraints to improving productivity for smallholder farmers in rural areas. The absence of clear ownership or lease agreements often limits farmers' access to credit and other financial services, which in turn affects their ability to adopt new agricultural technologies, such as conservation agriculture (Saqib *et al*., 2018 and Isaga., 2018).

Water scarcity is another critical challenge that directly affects smallholder farmers' livelihoods in SA. Many rural areas in the country suffer from insufficient rainfall, and farmers often rely on irrigation systems that are expensive and poorly maintained (Aguilar *et al*., 2022). The inefficiency of irrigation systems and unreliable water supply reduce agricultural productivity, contributing to food insecurity and poverty. To address these challenges, Rosa *et al*.,2020 and Li *et al*., 2020) highlight the need for sustainable water management practices that can improve water use efficiency, particularly in the context of conservation agriculture. Techniques such as rainwater harvesting and conservation tillage are vital in maintaining soil moisture and improving crop yields, particularly, for staple crops like maize (Mengistu., 2021).

Social factors also play a significant role in shaping the livelihoods of smallholder farmers. Social capital, such as community networks and support structures, is critical for farmers who are struggling to improve their productivity and resilience. According to the work of Skaalveen *et al*.,2020 and Chaudhuri *et al*., 2021, community support systems can provide smallholder farmers with access to information, financial resources, and collective action, which are essential for the adoption of technologies like conservation agriculture. Social capital also helps farmers cope with the effects of climate change and other external shocks by fostering collaboration and resource-sharing among farming communities (Wang *et al*., 2021).

The high levels of unemployment, poverty, and food insecurity in rural SA exacerbate the difficulties faced by smallholder farmers. Many households rely on farming, not only for food but also as a source of income, especially in areas where access to formal employment opportunities is limited. Low productivity in agriculture, due to factors such as poor soil fertility, climate change, and limited access to modern agricultural technologies, results in insufficient income for rural families. This creates a vicious cycle of poverty and food insecurity, where farmers struggle to meet basic needs. Interventions like conservation agriculture, which focus on improving agricultural practices and increasing productivity, are crucial in breaking this cycle and improving rural livelihoods (Abdullahi *et al*., 2024).

The context of livelihoods in SA is deeply influenced by a combination of economic, social, and environmental factors. Smallholder farmers, who form the backbone of the rural economy, face multiple challenges, including limited access to resources, climate variability, and socio-economic constraints such as poverty and food insecurity (Vhembe Agricultural Development Strategy, 2024). To enhance the livelihoods of smallholder farmers, interventions that focus on improving resource access, promoting sustainable agricultural practices like conservation agriculture, and building social capital are essential (Ntshangase *et al*., 2018). These efforts can increase productivity, improve income, and contribute to long-term improvements in the socio-economic well-being of rural households.

2.3.3 Maize production in the livelihoods of smallholder farmers

Maize is not only a staple food crop but also a key economic driver for smallholder farmers in rural SA, particularly in areas such as the Vhembe District. It plays a vital role in household food security, rural employment, and economic resilience. As the primary crop for many smallholders, maize is essential to meeting both subsistence and market demands. Erenstein *et al*., 2022 and Makgoba *et al*., 2021) found that over 60% of smallholder farmers in the Vhembe District grow maize, underscoring its pivotal role in rural livelihoods. The crop's significance extends beyond food consumption, as it serves as a source of income for many households, contributing to poverty alleviation and supporting local economies.

Maize is central to food security in rural communities, where access to diverse food sources is often limited. The crop is consumed in various forms, including mealie meal, which is a staple in many households, contributing to nutrition and overall well-being (Mufungizi., 2019). In areas with high food insecurity, such as the Vhembe District, where agricultural activities are often the only viable source of food, maize production helps mitigate hunger and malnutrition. According to an assessment by Grote *et al.,* (2021), maize farming provides a staple food for families and is critical in maintaining food sovereignty, especially in the face of market fluctuations and disruptions in food imports.

In addition to its role in food security, maize farming is a significant income-generating activity for smallholder farmers (Madimba ,2022). In rural areas where formal employment opportunities are scarce, maize serves to generate cash income, especially when surplus produce is sold at local markets or to larger buyers. This income is essential for covering other household expenses, such as health care, education, and other basic needs. Smallholder farmers who rely on maize for income can invest in other agricultural activities, improving their productivity and the diversification of their livelihoods. According to a study by Abokyi *et al*., *(*2020) & Appiah-Twumasi *et al*., (2020), the sale of maize not only helps farmers meet their household needs but also strengthens local economies by providing income to small-scale traders and improving rural employment.

Maize production, however, is not without challenges. The dependence on maize as a primary crop also exposes smallholder farmers to various risks, such as climate change, pests, and fluctuating market prices (Odeagbo *et al*., 2021 and Bedeke *et al*., 2018). Climate variability has led to unpredictable rainfall patterns, which directly impact maize yields. As a rain-fed crop, maize is highly vulnerable to droughts and floods, making it an unreliable source of income for many farmers. According to Prasanna *et al., (*2021) and Ahmad *et al*., (2020), climate variability has reduced maize productivity in many parts of SSA, including SA, leading to food shortages and income instability for smallholder farmers.

In the face of these challenges, efforts to improve maize production through sustainable farming practices, such as conservation agriculture, are gaining momentum. These practices help improve soil health, conserve water, and increase yields, making maize farming more resilient to climate variability (Corbeels *et al*., 2019 and Steward *et al*., 2018). Conservation agriculture techniques, including crop rotation and reduced tillage, are becoming popular among smallholder farmers, helping to stabilize maize production and ensure its continued role in local economies.

Maize production is fundamental to the livelihoods of smallholder farmers in rural parts of SA. It is essential for food security, income generation, and socio-economic well-being. Challenges, such as of climate change and market volatility highlight the need for innovative and sustainable agricultural practices to ensure the long-term viability of maize farming in these areas. Through improved farming techniques and better access to resources, smallholder farmers can enhance their resilience, ensuring that maize continues to be a cornerstone of their livelihoods.

2.3.4 Impact of climate variability on smallholder farming

Climate variability is a significant threat to smallholder farmers in SSA. Erratic rainfall patterns, prolonged droughts, and extreme weather events, like floods, have become more frequent and severe, making agriculture increasingly unpredictable. Smallholder farmers, who rely on rain-fed agriculture, are particularly vulnerable to these changes. The increasing unpredictability of rainfall has resulted in crop failures and reduced yields, threatening the food security of millions of people across the continent (Nyahunda and Tirivangasi*.,* 2022; Onyeke *et al*., 2021 and Shahzad *et al*., 2021).

In response to these challenges, smallholder farmers are turning to sustainable farming practices, like conservation agriculture. According to Kassam *et al*., (2019), conservation agriculture practices offer a solution to mitigate the negative impacts of climate change by improving soil structure, increasing water retention, and enhancing soil fertility. These benefits help to build resilience against drought and flooding, providing smallholder farmers with a more reliable agricultural system.

The characteristics of smallholder farmers in SSA, including - age, education, access to resources, and the socio-economic context - play significant roles in shaping their ability to adopt innovative farming practices, like conservation agriculture (Tama *et al*., 2021 and Oyetunde-Usman, 2021). While older and less-educated farmers may be resistant to adopting new technologies, younger, better-educated farmers are more likely to embrace conservation agriculture to improve productivity and enhance resilience to climate variability (Devkota *et al*., 2022 and Yang 2022). The challenges faced by smallholder farmers, including land fragmentation, limited access to resources, and poor infrastructure, must be addressed to promote the widespread adoption of conservation agriculture. Ultimately, the adoption of conservation agriculture in SSA holds great potential for improving food security, enhancing livelihoods, and building resilience to the impacts of climate change (Qaim, 2020).

In conclusion, empirical evidence highlighted the potential benefits of CA for smallholder maize farmers, highlighting its theoretical underpinnings, diverse methodological approaches, and empirical evidence regarding its impacts. Climate change and variability pose a significant threat to the livelihoods of smallholder maize farmers, where erratic rainfall, droughts, and rising temperatures have all led to reduced maize productivity. The vulnerability of these farmers is compounded by their limited resources and lack of adaptive capacity, however, climate-smart agricultural practices like conservation agriculture, offer a promising solution to mitigate the negative impacts of climate change. By improving soil health, increasing water retention, and enhancing resilience to climatic stresses, conservation agriculture provides smallholder farmers with the tools to adapt to the challenges posed by a changing climate and secure their livelihoods. Future research should focus on longitudinal studies that track the long-term effects of CA adoption on livelihoods, particularly as climate change continues to affect the agricultural systems.

2.4 Chapter summary

This chapter presented literature used which was dissected into three parts, the theoretical perspective, methodological and empirical perspective of CA. Moreover, characteristics so smallholder farmers in SSA, context of sustainability of livelihoods in SA and the impact of climate variability on smallholder farmers were outlined.

CHAPTER 3

RESEARCH METHODOLOGY

3.0 Chapter introduction

This chapter outlines the methodology for this study. To give a comprehensive understanding of how this research was conducted, the following sub-headings were described in detail: a description of the study area, the research design approach, population and sampling procedure, data collection, data analysis, ethical consideration, validity & reliability test and finally the expected outcome for this study. Outlining the methodology in the study was found essential because it explains exactly the guidelines on how the study was conducted.

3.1 Description of the study area

As shown in Figure 3.1, the study was conducted in the Vhembe District Municipality (VDM), which is classified as Category C. Category C Municipality are also referred to as District Municipality, comprises of larger jurisdiction which include several category B municipalities. The District Municipality focuses on development and infrastructure support across the entire district. Vhembe District was established in the year 2000 in terms of the Local Government Municipal Structures Act No. 117 of 1998 and is one of the five districts in the Limpopo Province. Vhembe District Municipality consists of four local municipalities (shown in Figure 3.1) located in the following coordinates: Collins Chabane (22°35´S 30°40´E), Makhado (23°00´S 29°45´E), Musina (23°20´17´´S 30°02´30´´E) and Thulamela (22°57´S 30°29´E); Tshivenda and Xitsonga are the most two dominating languages used by the residents. This researcher chose to conduct this study in the Vhembe District because it is an underdeveloped area which is characterised by high rural settlement patterns and dominated by impoverished rural communities. The agricultural sector in the Municipality is characterised by a diverse landscape consisting of both large-and small-scale farmers. Vhembe District Agricultural Strategy (2024) reported that smallholder farming in the District is composed of subsistence farming, with farmers cultivating crops primarily for local consumption and maintaining their livelihoods. Smallholder farming faces several challenges, including limited access to resources, inadequate infrastructure, limited market linkages, among others. Climate variability exacerbate the vulnerability of smallholder farmers, exposing

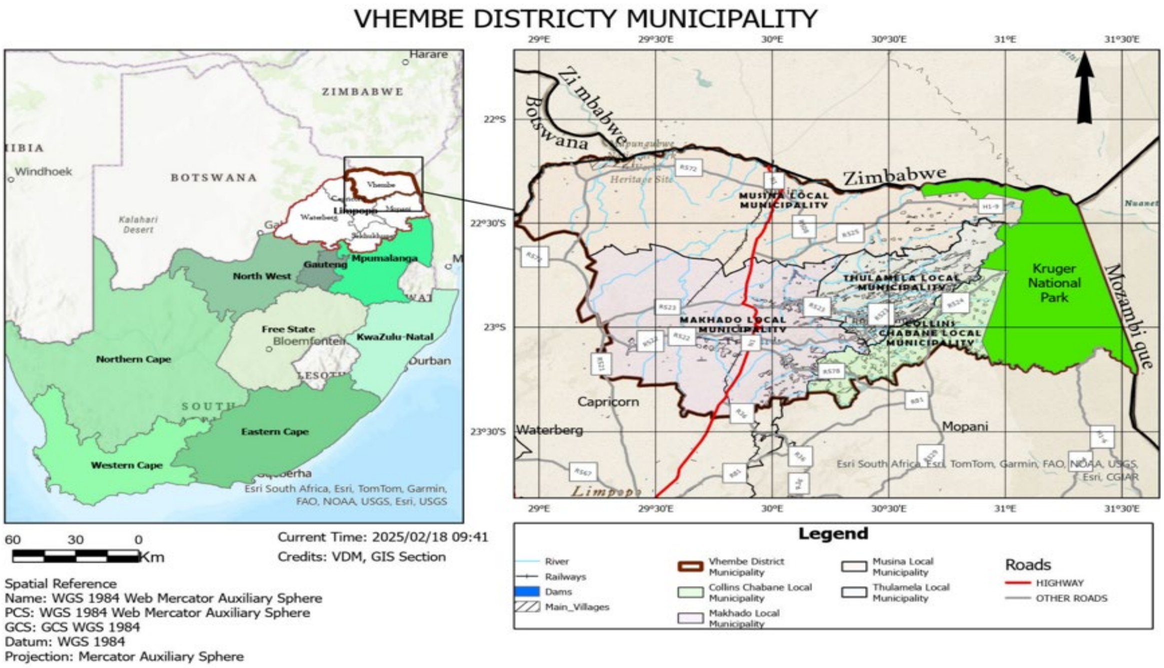

Figure 3.1: Vhembe District Municipality

them to disasters, such as pests, diseases and harsh climatic conditions which threatens crop production. Furthermore, Vhembe District Agricultural Strategy (2024) report concluded that the area must navigate the dynamics of globalization, including technology innovation and adoption of modern farming practices for the enhancement of productivity, efficiency and sustainability in the sector.

3.2 Research design and approach

Cresswell (2008) defines a research design as the "procedures for collecting, analysing, interpreting and reporting data in research studies". Babbie (2004) asserts that the best study design uses more than one research method, taking advantage of their different strengths.

This study was conducted as a descriptive survey following a concurrent mixed-method research design. A mixed-method design entails the collection and analysis of both quantitative and qualitative data in a single study, simultaneously, and involves the incorporation of data at one or more stages. Mixed-method approach has the benefit of providing data which a single approach cannot offer, hence, delivers a broader picture, by observing trends of generalizations as well as in-depth knowledge of participants' perspectives (Creswell, 2003; Gutmann & Hanson, 2002). Quantitative approach explains phenomenon by collecting numerical data that are analysed using statistical approaches. It is usually used to obtain information through methods, such as experiments and surveys and exploits predetermined instruments that yield statistical data; its strength is that it is reliable, quantifiable and generalizable to a larger population (Cresswell, 2008).

In this study, quantitative research practices were used by adopting an interpretative method based on participants' experiences through completion of field questionnaires as a way of qualifying with the requirements of quantitative research approaches. Cresswell (2008) states that a qualitative design focuses on explaining a phenomenon as it occurs in a natural setting. Its strength is that it has the potential to generate rich descriptions of participants' thought processes and focus on the reasons "why" certain phenomenon takes place.

In employing the qualitative research approach, knowledge was be obtained through a combination of field notes and focus-group discussions; these different sources later are summarised to consolidate high quality data sets. Both research approaches were considered appropriate for the study because of their general application of research techniques currently in use by researchers, in the field of human and social sciences.

3.3 Population and sampling procedures

3.3.1 Population

The Vhembe District smallholder maize farmers were the population for this study. Kish (1957) defined population as the set of units that the sample is meant to represent and the units that make up the population on the units of analysis. The overall population was (N=1 050) smallholder maize farmers who were called the respondents on this study. The respondent for this study comes from the four local municipalities in the Vhembe District as shown in Table 3.1 (summary of the population and sample). During the population sampling, the researcher worked closely with the public extension officers in the Vhembe District Department of Agriculture and Rural Development for database and guidance.

The specific criteria used to select the sample was that the farmer was farming maize a major crop, farming as smallholder, having adopted CA, either practicing one, two or all three principles of CA for a period of five-years and above.

3.3.2 Sampling procedure

Probabilistic sampling technique was used to select (N337) the participants in this study. Simple random sampling method was used as the sample selection method for this study. The Slovin's Formula was used to calculate the sample for this study,

Slovin's formula as follows: $$n = \frac{N}{1 + N \cdot e^2}$$

Where:
- n = sample size
- N = total population size (1,050)
- e = margin of error (e.g., 0.05 for a 95% confidence level)

The margin of error

$e = 0.05$: $$n = \frac{1050}{1 + 1050 \cdot 0.05^2} = \frac{1050}{1 + 2.625} \frac{1050}{3.625} \approx. 289$$

The sample was adjusted to the sample size to n350 based on factors such as anticipated non-response rates or data saturation, however, the sample size of n337 was finally used because thus the questionnaires which were completed fully.

Table 3.1 Summary of sample size per Municipality

Municipality	Total number of respondents	Total sample	Percentage
Thulamela	380	120	36
Makhado	300	100	30
Collins Chabane	210	80	24
Musina	160	37	10
Total	1 050	337	100

3.4 Data collection

Data for this study was collected using multiple research instruments. Neuman & Robson (2014) explain research instrument as an assistive tool or device that can be used to generate valuable and relevant information, from research participants, while conducting scholarly research.

In this study, a structured questionnaire was developed as the quantitative research instrument. A questionnaire is a document containing questions and other types of items designed to solicit information, appropriate for analysis (Babbie, 1990). Structured questionnaires include pre-coded questions with well-defined skipping patterns to follow the sequence of questions; most of quantitative data-collection operations use structured questionnaires. Advantages of such structured-questionnaires are - less discrepancies, easy to administer, consistency in answers and easy for the data management (Acharya, 2010). The questionnaire comprised of sections -demographic, farm status, knowledge of climate variability and conservation agriculture, financial report for maize farm, and practice of conservation agriculture and diversification of livelihoods.

In addition, data for this study was also collected using a qualitative research technique – focus group discussions. For this process, focus-group guideline was developed by the researcher to guide the discussions. The focus-group discussions guidelines were composed of five sections - climate variability observations, effect of climatic conditions on maize production, mitigation strategies, farmers' persistence with conservation agriculture practices and lastly the limitations of conservation agriculture practices. Two (2) focus-group discussions were held per municipality, thus the study held eight (8) focus-group discussions in total, with 10 – 12 members.

3.5 Data analysis

Data analysis is a process whereby the researcher incorporates different statistical techniques to analyse participants' responses in a quantifiable approach, such as through the use of inferential statistics or percentages (Creswell, 2008).

In analysing data, the study used the most representative variables in the study (defined in 3.5 of this chapter). Information obtained during data collection was transformed into the language that the computer assimilates, during data analysis (Kumar & Srinivas, 2010). In this study, all completed questionnaires were coded and captured into excel spreadsheet for statistical analysis.

Data for this study was analysed and interpreted using statistical software which were incorporated with automated statistical techniques (descriptive and inferential statistics) such as figures, tables with percentages suitable to present quantitative and qualitative results. Quantitative data was presented by means of frequency tables, graphs and charts. Bar charts were presented in a horizontal format wherein the N represents the number of respondents for each question. Qualitative data was analysed using Thematic Analysis. Data was coded using coding frameworks, themes were identified, developed, interpreted and finally reported using a table. The following were specific techniques and statistical methods used for analyzing the data:

3.5.1 Descriptive analysis

To analyse and interpret data on characterisation of smallholder maize farmers, data was analysed and interpreted using statistical software which were incorporated with automated statistical techniques. Descriptive and inferential statistics such as figures, tables with percentages suitable to present quantitative and qualitative results. Quantitative data was presented by means of frequency tables, graphs and charts. Bar charts were presented in a horizontal format wherein the N represents the number of respondents for each question. Qualitative data (focus group discussion data) was analysed using Thematic Analysis. Data was coded using coding frameworks, themes were identified, developed, interpreted and finally reported using a table.

3.5.2 Cross-tabulation and Chi-Square analysis

To determine factors significantly influencing the adoption of CA, cross-tabulation analysis and chi-square test was used. Cross-tabulation analysis created a contingency table which displayed the frequency distribution of two categorical variables (e.g., adoption of CA and potential influencing factor). P-value was determined where if the p-value is below 0.05 the relationship between variables was statistically significant. Factors used in determined to influence the adoption of CA included demographic factors (age, gender, level of education, farm income for household head, farm size, access to extension service, knowledge for CA and access to agricultural training).

Chi-Square (x^2) Test Formula

$$X^2 = \sum \quad [\frac{(observed\ frequency - expected\ frequency)2}{expected} frequency$$

The findings on factors influencing the adoption of CA were presented in this report (chapter 5) in the form of tables.

3.5.3 Ordinal Logistic Regression (OLR)

To further determine factors influencing the adoption of CA, Ordinal Logistic Regression (OLR) was used. The following socioeconomic factors were used to on OLR (age, training, education, knowledge and access to extension). The proportional odds assumptions were generally supported (nominal test p>0.05 for most predictors). The OLR model was fit because of its flexibility (can handle multiple independent variables, both categorical and continuous variables) and predictive power (can predict the probability of an outcome falling into a particular category).

The following is the formula for Ordinal Logistic Regression (OLR) Model

logit(P(Y ≤ j)) = α_j - (β1 * Age + β2 * training + β2 * education + β3 * knowledge + β4 * Access_to_extension)

Where:

- *Y*: Ordinal dependent variable (adoption of Conservation Agriculture)
- *j*: Category of the dependent variable (e.g., non-adoption, partial adoption, full adoption)
- *α_j*: Threshold parameter for category j
- *β1, β2, β3, β4, β5*: Coefficients for the independent variables
- *Age (31-40/41-50/51 and above)*: Age of the farmer
- *Training (yes/no) *: CA training received
- *Education (primary/secondary/tertiary)*: Education level of the farmer
- *Knowledge (poor/average/good/very good)*: Knowledge about Conservation Agriculture
- *Access_to_Extension (yes/no)*: Access to extension services

Model fit:

-The proportional odds assumption was generally supported (nominal test p>0.05 for most predictors).

- Significant thresholds indicate clear separation between adoption and categories.

3.5.4 Gross margin analysis

To estimate the profitability for maize production under CA, gross margin analysis was conducted where the distribution of five-year average economic profitability of smallholder maize farmers was assessed.

The formula for calculating gross margin is as follows:

[{Gross Margin} = {Total Revenue} - {Total Variable Costs}]

Where:

-Total Revenue is the income generated from selling maize, calculated as:

[{Total Revenue} = {Price per Unit} times {Total Quantity Sold}]

-Total Variable Costs include all direct costs that vary with the level of production.

Gross margin analysis provides the understanding of economic implications and act as an indicator of financial health and efficiency of a farming practice.

3.5.5 Multiple Linear Regression

Finally, to further assess economic viability for maize production under CA, Multiple Linear Regression (semi-log, linear-log model and double-log model) was employed as follows:

3.5.5.1. Semi-log Model

Model specification:

$$\log(\text{Profit1} + c) = \beta_0 + \beta_1 \cdot \text{Age\_31–40} + \beta_2 \cdot \text{Age\_41–50} + \beta_3 \cdot \text{Age\_51+} + \beta_4 \cdot \text{Gender\_Female} + \beta_5 \cdot \text{Education\_Primary} + \beta_6 \cdot \text{Education\_Secondary} + \beta_7 \cdot \text{Education\_Tertiary} + \beta_8 \cdot \text{Experience\_4–6} + \beta_9 \cdot \text{Experience\_7–10} + \beta_{10} \cdot \text{Experience\_11–15} + \beta_{11} \cdot \text{Experience\_>15} + \beta_{12} \cdot \text{Inputs} + \beta_{13} \cdot \text{Training\_No} + \beta_{14} \cdot \text{Extension\_No} + \beta_{15} \cdot \text{Knowledge\_Poor} + \beta_{16} \cdot \text{Knowledge\_Average} + \beta_{17} \cdot \text{Knowledge\_Good} + \beta_{18} \cdot \text{Rotation\_Yes} + \beta_{19} \cdot \text{Mulch\_Yes} + \beta_{20} \cdot \text{Notillage\_Yes} + \varepsilon$$

3.5.5.2. Linear-log Model
Model specification:
Profit1 = $\beta_0 + \beta_1 \cdot \log(\text{Inputs}) + \beta_2 \cdot \text{Age\_31–40} + \ldots + \beta_{20} \cdot \text{Notillage\_Yes} + \varepsilon$

3.5.5.3. Double-log Model
Model specification:
$\log(\text{Profit1} + c) = \beta_0 + \beta_1 \cdot \log(\text{Inputs}) + \beta_2 \cdot \text{Age\_31–40} + \ldots + \beta_{20} \cdot \text{Notillage\_Yes} + \varepsilon$

Note:
- Reference categories (not shown explicitly in the model) are:
  • Age: ≤30 years
  • Gender: Male
  • Education: No formal education
  • Farming experience: ≤3 years
  • Training and Extension: Yes
  • Knowledge: Very poor
  • Rotation, Mulch, No-tillage: No

Table 3.2: Multiple Linear Regression Model

Model	AIC	BIC	Adjusted R^2	Interpretation
Linear	2316.09	2400.07	0.124	Weak fit
Semi-log	157.97	241.95	0.229	Best fit;
Linear-log	2340.39	2424.37	0.058	Lower fit;
Double-log	210.87	294.84	0.098	Moderate fit

3.5.6 Analysis of Variance

Analysis of variance for CA profit was used to understand the interaction and influence of CA principles (significance of predictors) on maize profit. The finding was reported using means and frequency.

3.6 Definition of variables and measurements

Age was defined as the respondent's chronological age in years in the form of categorical data (e.g. age of a farmer below 30; between 31-40; 41-50; 51 and above). Age reflects the ability of a farmer to understand and invest physical activity and risks associated with the farming technology.

Education was defined in terms of the highest level of formal schooling completed or the total years of formal education. It reflects a farmer's capacity to access and process new information. Level of education is measured either no schooling/ primary education/ secondary education and tertiary education.

Farming experience refers to the number of years the respondent has been engaged in maize farming activities. It is used to capture both accumulated practical knowledge and the maturity of farm management skills. Farming experience was measured by collecting a self-reported number of years the respondent has been involved in farming in a categorical manner ("between 1-3 years"; "between 4-6 years" "between 7-10 years"; "between 11-15" and "more than 15 years").

Five (5)-year Inputs variable was used to represent the use of agricultural inputs (such as improved seeds, fertilizers, pesticides, and other amendments) over the previous five years. It focused on the intensity, frequency, or diversity of inputs used in the maize farming system.

Access to extension service variable refers to the farmer's ability to contact and receive advisory services provided by government agencies, NGOs, or private entities, which offer technical support and information. Access to extension service was measured as a binary variable where the respondents were asked whether or not they have access to extension services.

Conservation Agriculture knowledge variable was captured as the farmer's awareness and understanding of CA principles (e.g., no tillage "minimal soil disturbance", mulching "permanent soil cover", crop rotation/ diversification), which are critical for sustainable land management. Conservation Agriculture knowledge variable was treated as a categorized variable (e.g., no, poor, good or very good).

3.7 Ethical Considerations

To ensure that ethical research was conducted, the researcher presented the research proposal to the Higher Degree Committee (HDC) of the University of Venda seeking Ethical Clearance Certificate (ECC) after approval of the research proposal. During data collection, the research team adhered to all ethical conduct by explaining ethical procedures and protocols to the participants for this study. Participants were also informed that they have the freedom to express themselves in any language of their choice. All research participants were further informed that their involvement in the study was voluntary, and without any remuneration attached to it. Participants were further reminded that their shared views, opinions and viewpoints will be kept confidential to the research team. Further, the participants were promised to receive feedback for this study. No names were recorded on any research instrument except that participants' register was kept, in accordance with Covid-19 protocols only. All ethical procedures were undertaken as precautions to protect participants' dignity, right to privacy and confidentiality of information. Clearance Certificate for this study is attached to this research report as an annexture.

3.8 Validity

Validity of research instrument is the ability of an instrument to measure what it is supposed to measure, with the purpose of producing valid results (Babbie & Mouton, 2011, Flick, 2015 & Taherdoost, 2016). In this study a combination of content and face-validity was used to validate questions asked with each of the research instruments (questionnaire, focus-group discussions). This type of validity was chosen for the study because it provides detailed informative justifications to enable broader understanding of research questions and statements by research participants. In addition, it has the ability to provide personal face-to-face contact sessions with research participants, in line with concurrent mixed method, such as completion of questionnaires, focus-groups discussions and interviews.

A pilot test of each research instrument was conducted with at least five (5) representatives of the targeted participants who did not taken part in the final study during data collection. The population for pilot testing was drawn using convenient sampling. This was done to measure the accuracy of each research instrument with the sole purpose of removing any language ambiguity and less informative questions or statements. The pilot test helped re-shaping the research instruments by identifying ambiguity and evaluating response options.

3.9 Reliability

In this study, internal consistency method was considered suitably because it required a once-off administration of research instrument, undertaking careful observation and proper handling of participants' information. Most researchers (Leonhard *et al*., 2000; Vaske *et al*., 2017 and Hajjar.,2018) in the field of human and social science research recommend the use of internal consistency methods for field study because of its effectiveness. In addition, research participants' data obtained from large sample size using concurrent mixed methods research approaches were found to have high reliability and probability ratio. This study, therefore, complied with all the requirements of mixed-methods research design for selecting large sample size of different segments, who share similar characteristics, knowledge and experiences, sought by the researcher.

3.10 Chapter Summary

This chapter gave an overview of the research methodology used in this study. The outline included - presenting the study area, targeted population, sample size, data collection instruments, data analysis techniques, ethical considerations, validity and reliability testing done in this research.

CHAPTER 4

CHARACTERIZATION OF SMALLHOLDER FARMERS PRACTICING CONSERVATION AGRICULTURE IN VHEMBE DISTRICT

4.0 Chapter introduction

In this chapter is presented the results on the characterization of smallholder farmers practicing conservation agriculture in Vhembe District. The results were based on biographical data used to characterize smallholder farmers - gender, age, level of education, farming experience, farm size, crops planted, level of adoption of conservation agriculture, the adoption of conservation agriculture by principles, training received, lastly, knowledge of conservation agriculture.

4.1 Descriptive results

As presented in Table 4.1 - age, gender, marital status, household size and the level of education - are characteristics of smallholder maize farmers in the Vhembe District. These characteristics influence decision-making, whether to adopt, adapt or dis-adopt a particular farming technology. The goal for characterizing the respondents was to build a base from which to have further understanding of adoption and benefits from conservation agriculture.

The results in Table 4.1 show that more than half of the respondents were female (53.71%); this could be because culturally, most of the farm duties are carried out by females. Male members of the society are usually engaged in other livelihood opportunities outside farming. It could also be due to gender roles that keep women around their homes, hence, their only option is farming that will allow them to double as home-makers, as well. Culturally, women were not given equal opportunities to education which limited their skills-set to engage in other livelihood opportunities. Gender may influence the decision of a participant to either adopt, adapt or dis-adopt labour-demanding farming technologies, such as conservation agriculture.

Figure 4.1 illustrate that majority (66.77%) of the respondents were above 51 years of age while only 8.01% were 30 years and below. Years spent on farming may also be another encouraging factor. Age of a farmer could influence the probability of adoption of new technology. Labour demands in the farming technology may also compel the aged farmers not to participate if they cannot match the needs. On the contrary, younger farmers may not be concerned about labour demands and the risks attached to the conservation agriculture farming technology, if they value the benefits.

In terms of education level, Table 4.1 shows illustrate that about 10% of the participants have no formal education while close to 21% have acquired primary education. About 40% have completed secondary education while 32.34% have acquired tertiary education. Education level of a farmer may encourage or discourage the adoption or practice of a new technology and may be associated with a better understanding of environmental necessities. Educated participants tend to seek more information about the environmental risks and mitigation strategies thereof. The level of education for a participant may influence the level of acceptance and proper application of a technology, while it may also discourage adoption if the loss outweighs the benefits.

As shown in Table 4.1, more than half of the respondents (51.04%) did not have access to extension services, while 48.96% do. This could be because most of the respondents may have lost confidence with the extension system due to information gap. Extension services play a vital role through disseminating farming information such as environmental conservation, climate variability and conservation agriculture practices.

Extension practitioners, however, must be empowered with current agricultural procedures so that they can disseminate relevant information. Knowledge-rich farmers may choose not to attend extension sessions if they notice information gap among extension practitioners. Farmers who access extension services may have higher probability of conservation agriculture adoption if information about environmental conservation and conservation agriculture practice is clearly disseminated.

Table 4.1: Demographic results for the participants

Characteristics		Frequencies	Percentage
Gender	Female	181	53.71
	Male	156	46.29
	Total	**337**	**100**
Age	50 and above	225	66.77
	Between 41 and 50	48	14.24
	Between 31 and 40	37	10.98
	30 and less	27	8.01
	Total	**337**	**100**
Level of education	Secondary education	125	37.09
	Tertiary education	109	32.34
	Primary education	70	20.77
	No formal education	33	9.8
	Total	**337**	**100**
Access to extension service	No	172	51.04
	Yes	165	48.96
Total	**Total**	**337**	**100**

Regarding farming experience, Figure 4.1 indicates that more than half (51%) of the respondents have more than 15 years of farming experience while 10% had only 5 years' experience. The implication is that most of the respondents have adequate experience in agriculture to adopt conservation agriculture. Age of the farmers could also be another contributing factor in gaining more than 15 years of experience, hence, despite more farming experience, aging may prevent farmers from performing some physical activities on their farms

Most of the participants may have gained many years of farming experience as this is likely to be the best possible available economic activity given their skills or due to lack of employment opportunities.

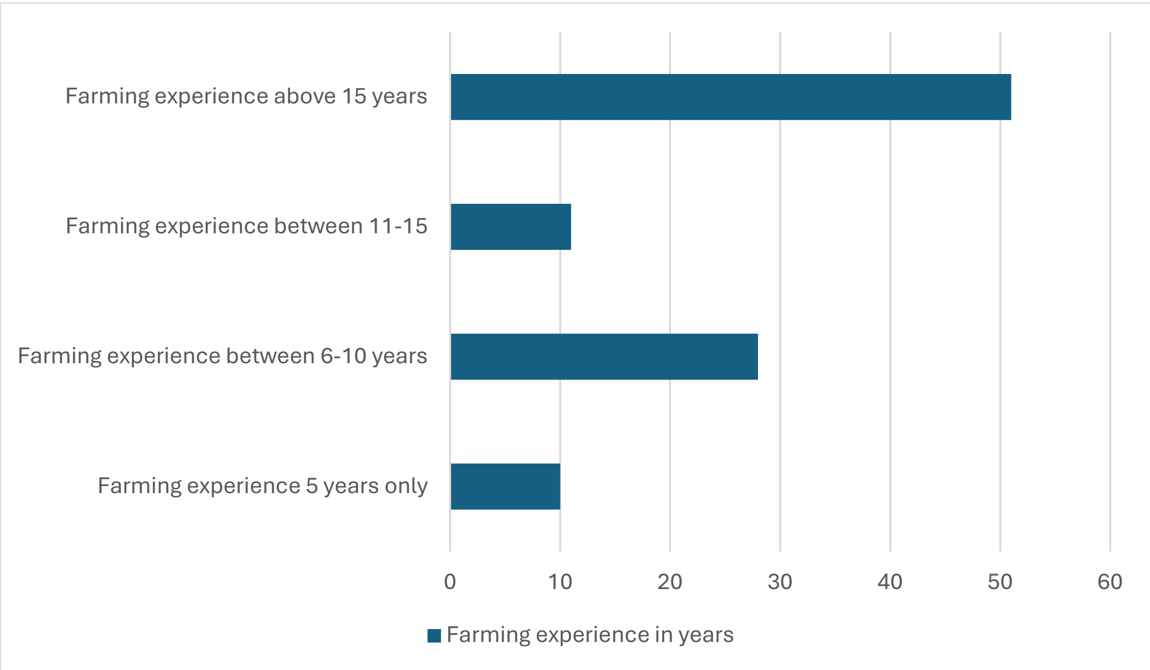

Figure 4.1: Farming experience of the respondents

Figure 4.2 illustrate that the highest proportion (75.7%) of the participants are farming on less than 2-hectare land size, followed by 16.3% who farm on greater than two but less than five hectares of farmland and lastly only 8.0% of the participants farm on more than five-hectares of land. These findings imply that about majority of the respondents are farming on a smaller land of less than two-hectares, while only a smaller number of the respondents are farming on more than five-hectare land. This result could be attributed to the fact that the study area is in deep rural area where most farmers use communal land under the local chief, moreover, they are only permitted to use the land without claiming ownership.

Pre-and post-apartheid land distribution restricted land access to black communities (only 13% of the land was allocated to black South Africans). Consequently, the marginalisation of blacks could be felt much more by the rural farming communities whose livelihoods depends on efficient land use. Larger land holdings in farming could be associated with farming for wealth and may encourage soil conservation measures like implementing conservation agriculture practices to sustain farm production.

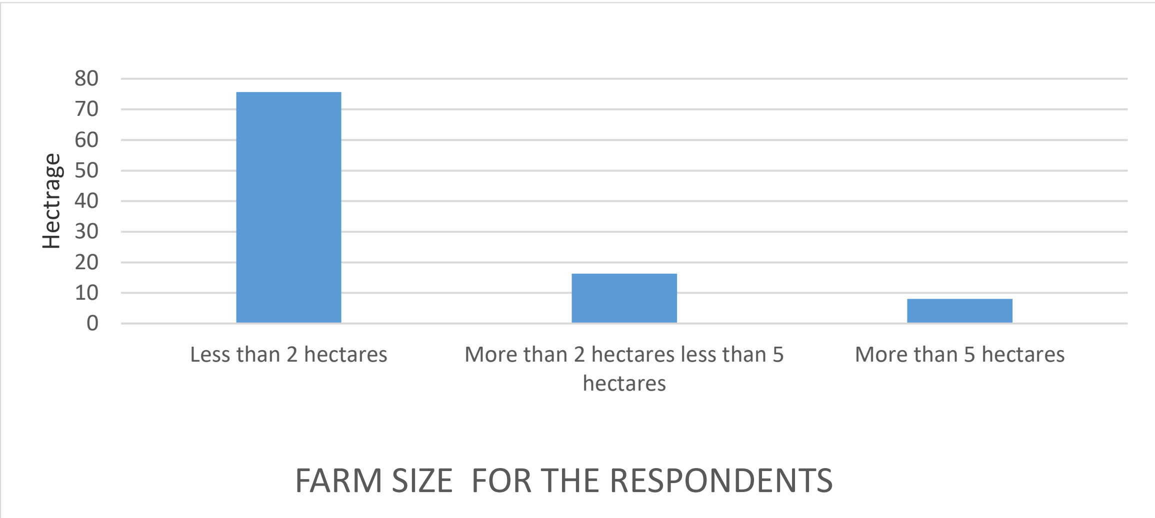

Figure 4.2: Farm size for the respondents

Majority of the respondents (61.42%) as illustrated in Figure 4.3 indicated that they plant maize as their major crop, followed by (38.58%) who plant other crops. This suggests that maize is planted by majority of farmers and that maize may be intercropped with other leguminous crops like ground nuts. Crops planted in the farm determine yield per crop season, moreover, a good farming method incorporated with the willingness to plant many crops may have a better yield than using an ordinary outdated farming method. A good farming technology, therefore, contributes to a better yield, especially, given the unpredicted weather patterns and the hiking prices of production inputs.

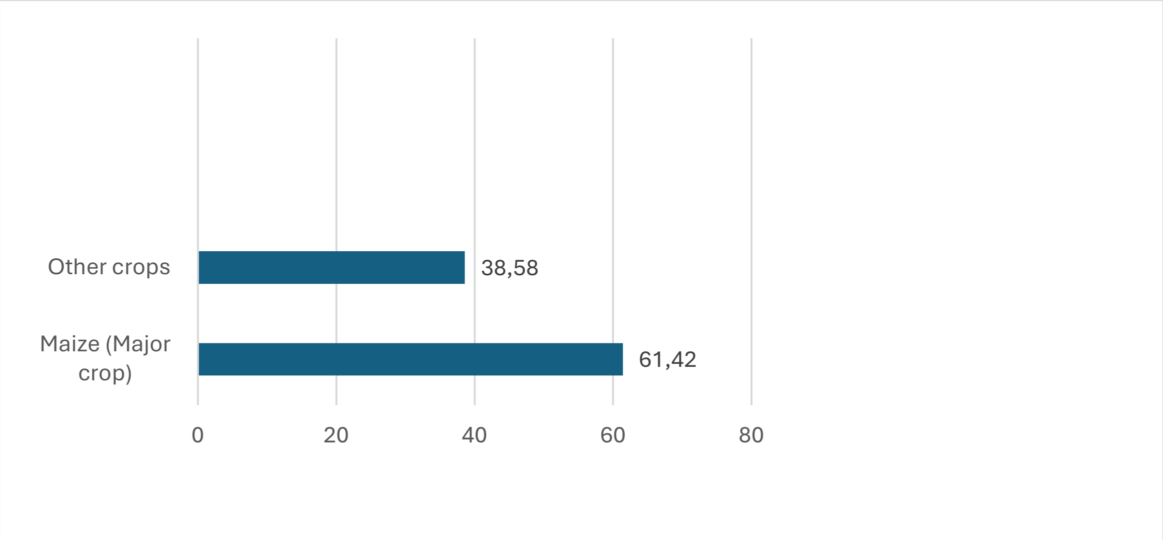

Figure 4.3: Crops planted by the respondents

Concerning conservation agriculture principles adopted by the respondents, Figure 4.4 illustrates that more than three quarters (76%) of the farmers adopted conservation agriculture principles partially; 16% did not comment on CA adoption while only 8% have fully adopted the principles. Partial conservation agriculture adopters are those respondents who are either practicing one or two principles out of the three interlinked principles of conservation agriculture. The interlinked principles of conservation agriculture are: (1) minimal soil disturbance (no-till), (2) maintaining and permanent soil cover using at least 30% of crop residues (mulching) and (3) crop rotation or intercropping (crop rotation).

These results could be because the respondents find it difficult to practice some of the conservation agriculture principles due to conflict of interest. If respondents, for example, have some livestock, they may opt to let their animals graze in their farm fields feeding on residues than keeping them to practice or maintain permanent soil cover using those residues, thus, for them feeding their livestock with residues is cheaper than buying livestock feeds, in times of needs.

Also, for those respondents who do not own livestock, they may lack fencing materials to protect their residues from grazing animals. Moreover, residue collection and laying could be labor-intensive and serve as an off set for adoption. Partial adoption of conservation agriculture may not yield the same harvest as holistic adoption involving practicing all three interlinked principles concurrently.

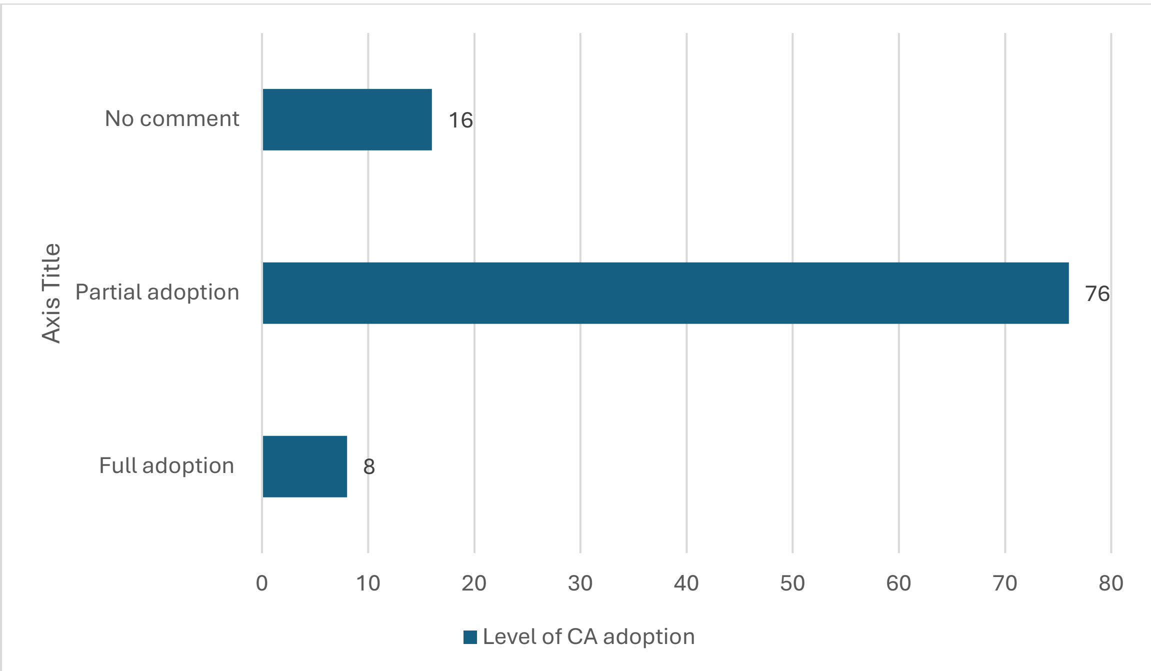

Figure 4.4: Level of CA adoption

Table 4.2 shows that the least adopted principle of conservation agriculture is mulching (4.75%), whereas crop rotation is the most (24.93%) adopted. This perhaps mean that most farmers are into crop-livestock farming, hence, they may not opt for mulching using residues. The participants revealed that they may be unable to practice all three principles of conservation agriculture, optimally.

Out of the three principles of conservation agriculture, the participants divulge that mulching was difficult to practice. These may be attributed to lack of training and knowledge as shown by training received by the respondents (Figure 4.4), thus, if the benefits of mulching are not emphasized during trainings, the respondents may not deem it valuable in their farms. Besides, another off-set on the application of mulching may be the time taken by the residues to become beneficial to the soil, thus, the respondents may not like residue decomposition processes and long time before benefits show. Mixing conservation agriculture with other practices may retard the adoption of mulching, for example, respondents who believe in burning residues after a crop season may continue to burn if they lack knowledge of the residue benefits.

The adoption of crop rotation by most of the respondents could, also be attributed to market demand; for example, the respondents may opt to plant and supply the available market rather than practicing monoculture for own consumption only. The availability of seeds or seedlings and the simplicity of crop maintenance may be another plausible reason why the participants practice crop rotation more than other principles of conservation agriculture.

4.2: Adoption of CA per principle

Principle	Frequencies	Percentage (%)
Mulching	16	4.75
Crop rotation and mulching	25	7.42
No-till, crop rotation and mulching	27	8.01
No-till	29	8.61
No-till and mulching	29	8.61
No comment	55	16.32
No-till and crop rotation	72	21.36
Crop rotation	84	24.03
Total	**337**	**100**

Pertaining conservation agriculture training received, the results (Figure 4.5) indicate that majority (61%) of the respondents have received partial training (trained on one, two or three principles of CA) in conservation agriculture principles; 18% have received full training and while 21% were not willing to give information on received training in any of the principles. The fact that more than half of the respondents have received partial training (neither trained on one nor two out of the three principles of CA) on CA implies that there is a general awareness of the CA practices even from farmer-to-farmer sharing of information.

Training may be key to the adoption of a new technology. Receiving training by the respondents may give them more knowledge and confidence on CA which may trigger their decision to adopt or sustain the practices. Consequently, full training on conservation agriculture may pave ways to its full adoption by the respondents while having no training on conservation agriculture may be a deterrent to adoption.

Conservation agriculture training may have to be continuous for the respondents to keep them informed and give then a platform to seek clarity on challenges which may come with the adoption of CA and keep them on. Receiving timely training on CA may determine the level of adoption by the respondents, these may again inform if whether the respondents are keeping their adoption level status or dis-adopting the principles.

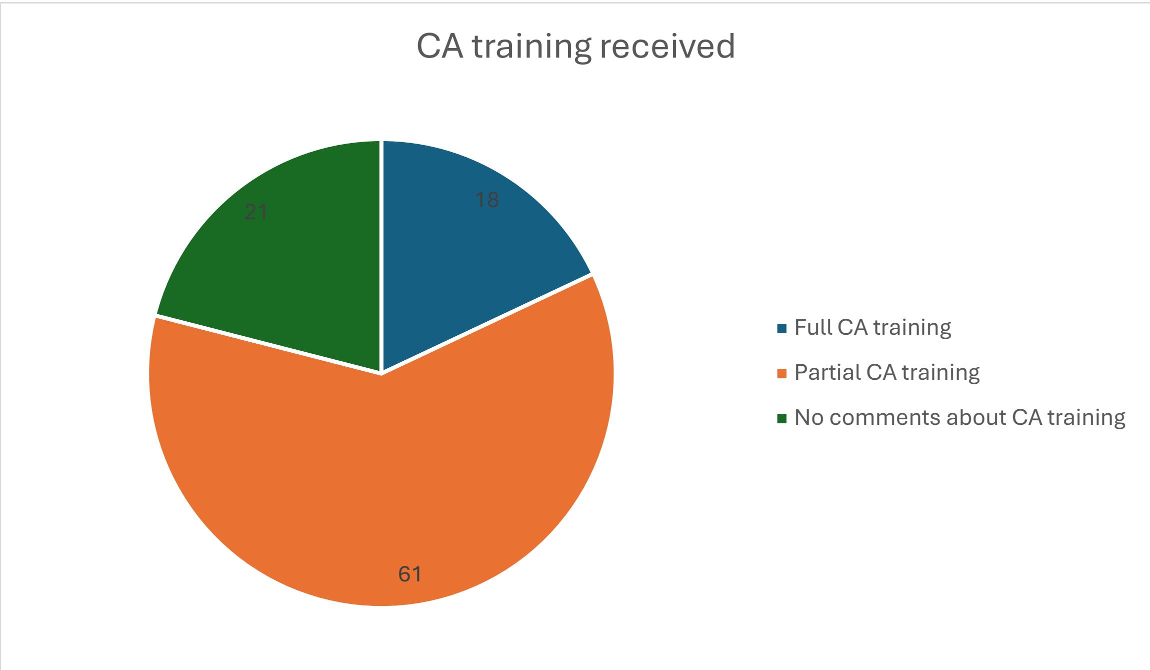

Figure 4.5: Conservation agriculture training received

With regard to knowledge of CA principles, Figure 4.6 shows the level of knowledge attained by the respondents. More than 30% of the respondents have poor knowledge while about 20% did not comment about their knowledge of CA. Lack of knowledge for CA by the respondents could be attributed to their understanding and attitude towards CA training received. Only 17.51% have received full training on CA practices while about 82% receive partial training, that the aim was to improve the use of agricultural resources through combined management of soil, water and biological resources. If well disseminated, this knowledge may result into optimum adoption of conservation agriculture.

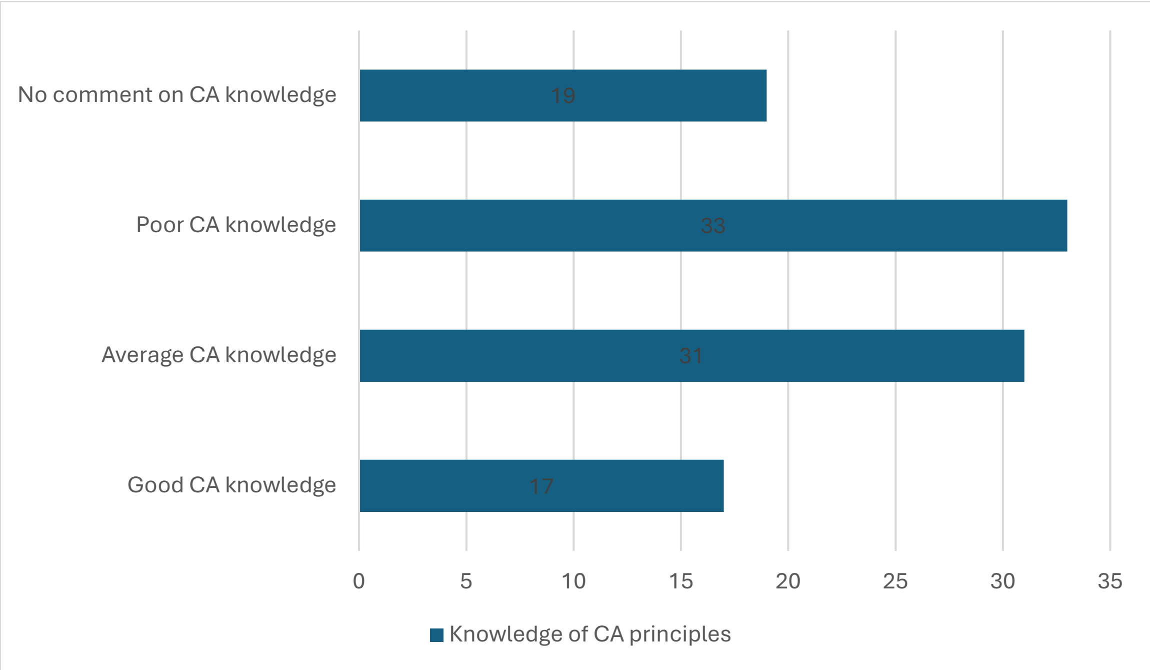

Figure 4.6: Knowledge of Conservation Agriculture

4.2 Discussion

The biographical results for the participants of this study shows a higher proportion of female as compared to male counterparts. These finding corroborate Stats SA (2022) and Vhembe Agriculture Development Strategy (2024) which reported the dominance of females in the Vhembe District agricultural sector. Female dominance in agriculture could be attributed to proximity to residential area where females find it easy to access the farms without worrying about transport cost since unlike mines, rural farms are in residential areas. Prior studies in

Kenya (Nyang'au *et al*., 2021) and Malawi, (Chinseu *et al*., 2019) have reported similar findings where women dominated participants in their studies. The domination of female participants may have an impact on the practice of conservation agriculture.

Majority of the respondents were above 50 years of age while youth were in minority. The dominance of the elderly farmers could be because of their economic reliance on the agricultural sector which also give them more farming experience, hence, majority of the participants indicated that they have more than fifteen years of farming experience. Similar findings have been reported in Nigeria, with Osabohien *et al*., (2022) reporting less participation by youth in agriculture as a primary occupation.

In the Vhembe District, Materechera and Scholes (2022) reported that most of their participants where aged 60 years upwards and identified agriculture as their main source of livelihoods. Experienced farmers have higher probability of increasing farm yields because previous loss may not have influenced future farm practices, however, age of a farmer may have adverse effect on physical ability in terms of farm duties, resulting in decreased farm yields and hampering the sustainability of their livelihoods.

Concerning education, majority of the participants have attained secondary education and above. Education is associated with understanding and informed decision-making. This suggests that majority of the participants for this study have higher probability of understanding farming techniques like conservation agriculture. Similar result has been reported in other parts of Africa (Prokopy *et al*., (2019) and in UK by Ruzzante *et al*., (2021) who concluded that formal education may likely correlate with the adoption of conservation agriculture. In USA, Peneiro *et al*., (2020) note education as a continuum within the adoption of conservation agriculture. Education of a farmer may positively influence proper practices of agricultural practices, increasing farm yield and thereby improving their livelihoods.

These results further indicate that more than half of the participants have no access to the extension service. This result is consistent with the findings in Zimbabwe, (Moyo and Salawu, 2018) that indicated that extension services were not adequately accessible to their respondents. These results could be attributed to the extension officers and farmers' ratio (1:250-FAO, 2018), wherein there are many farmers to be serviced by one extension officer. Technical knowledge disseminated by extension officers is vital for proper application of farm technology and productivity, therefore, inadequate extension services have higher probability of decreasing yield.

The result further revealed that most of the participants were farming on less than two-hectares of land, while minority were farming in less than five hectares. Land is associated with wealth. This finding suggests that majority of the participants did not have enough farmland. Land issues have been a long-debated topic in South Africa (Fanadzo and Ncube (2018); Zantsi (2020); Mijuru and Obi (2020); Thinda *et al.,* 2020). Farm-size identifies smallholder farmers from other categories of farmers and land is a fundamental component of farm production. Lacking enough land for farming can lead to a higher probability of limiting the practice of new farming technologies due to fear of risks attached to the technology.

Majority of the participants were planting maize, followed by ground nuts and lastly mixed vegetable; the choice of crops planted by farmers is associated with the benefits thereof. The Food and Agriculture Organization Statistics (FAOSTAT-2019) and findings from Laudine *et al*., (2020), in Kenya note the domination of maize in food security.

Lack of residues for mulching could explain partial adoption of conservation agriculture by the participants. This result is consistent with the findings in Bangladesh (Sarkar, 2020) and in India (Koul *et al.,* 2020) who identified residue burning as a major challenge in conservation agriculture adoption. Intensive labor in conservation agriculture could also explain its partial adoption. Similarly, this result is consistent with the findings in Malawi (Makate *et al*., 2019) and Southern Africa (Somasundaram *et al*., 2020) where they reported partial adoption of conservation agriculture. Partial adoption of conservation agriculture has higher probability of retarding some of its benefits.

Crop rotation was revealed to be the most adopted principle of conservation agriculture while mulching was the least adopted. The choice of a crop to be planted could be explained by the underlying benefits thereof. This suggests that the participants have been enjoying the advantages in rotating crops more than from the other principles of conservation agriculture. This result is consistent with the findings in Malawi (Ogieriakhi *et al*., 2022) and Bouwman *et al*., (2020) who reported that not all three principles are adopted simultaneously. These could be attributed to land availability as alluded before in this current study where most of the participants were farming on less than two hectares. Small farming area (less than five hectares) have a higher likelihood of inhibiting the practice of new agricultural techniques due to fear of loss for profit which has a higher probability of hampering livelihoods of the participants.

Partial adoption of CA could be explained by lack of training on CA and poor knowledge. Knowledge is a powerhouse for proper performance. The result suggests that very few participants have received training while most of the participants have poor knowledge on conservation agriculture. The findings are consistent with prior studies (Tama *et al*., 2021) where it was found that knowledge correlated with the adoption of conservation agriculture. Trained and knowledgeable farmers have a higher likelihood of encouraging other farmers to participate in the practice of agricultural technology. Training and knowledge in a good agricultural technology have a higher probability of increasing yield, thereby enhancing livelihoods for the participants.

4.3 Chapter summary

This chapter characterized smallholder farmers in Vhembe district to align the agricultural intervention with the needs of the participants. The results indicate that majority of the participants were elderly female (above 50 years of age) with more than 15 years of farming experience. More than half of the participants have acquired secondary education and beyond, however, three quarters of participants were farming on less than 2-hectare land, while planting maize as a major crop. Further, more than three quarters of the participants have adopted conservation agriculture partially, with crop rotation being the most adopted principle while mulching was the least adopted. This result was attributed to partial training on conservation agriculture which was also displayed by lack of knowledge by half of the participants.

CHAPTER 5

DETERMINATION OF FACTORS INFLUENCING THE ADOPTION OF CONSERVATION AGRICULTURE PRACTICES BY SMALLHOLDER MAIZE FARMERS IN THE VHEMBE DISTRICT

5.0 Chapter introduction

In this chapter, the researcher presents results on the factors influencing the adoption of conservation agriculture practices by smallholder maize farmers in the Vhembe District. Understanding these factors is essential for targeting interventions supporting smallholder farmers' adoption of conservation agriculture. These results may indicate conservation agriculture's symbiotic aspects, which may be significant drivers for its adoption. These factors may serve as a barometer to assist the respondents to adopt climate change mitigation technologies (conservation agriculture), thereby building resilience in food production while enhancing their economic livelihood.

5.1 Results on determinants of adoption of CA

The results in Table 5.1 show a statistically significant (p=0.005) relationship between CA and the age of the respondents. This result suggests that age of a farmer may influence the adoption of conservation agriculture, whether, no-till, crop rotation, mulching or both. As observed (Table 5.1), the highest number who have practiced crop rotation was in the 50 years of age. This result could be because farmers find crop rotation more easily applicable, surpassing mulching and no-till due to seed availability.

Table 5.1: Adoption of conservation agriculture by age

Conservation agriculture principles	Age of participants				Total	P-value
	30 years and less	Between 31 and 40 years	Between 41 and 50 years	50 years and above		
No-till	1	4	6	22	33	
Crop rotation	13	11	13	63	100	
Permanent soil cover/ mulching	7	3	3	5	18	
No-till, crop rotation, and permanent soil cover/mulching	2	3	4	20	29	0.001***
No-till and crop rotation	2	6	5	39	52	
No-till and permanent soil cover	0	1	4	15	20	
Permanent soil cover and crop rotation	1	5	2	12	20	
No comment	2	5	8	50	65	
Total	28	38	45	226	337	

Research survey, 2023

Note: ***, ** and * mean the coefficient is statistically significant at 1%, 5% and 10%, respectively. Number of observations=337

The results in Table 5.2 reveal that there is no statistically significant relationship between gender and the adoption of conservation agriculture practices among smallholder maize farmers in the Vhembe District, as indicated by a p-value of 0.217. This lack of statistical significance suggests that any observed differences in conservation agriculture adoption between male and female farmers are likely due to chance rather than any underlying, consistent gender-based factor. In other words, both male and female farmers showed similar patterns in adopting conservation agriculture practices, implying that gender is not a strong determinant for conservation agriculture adoption in this context.

Table 5.2: Adoption of CA by gender

CONSERVATION AGRICULTURE PRINCIPLES	GENDER		TOTAL	P-VALUE
	Male	Female		
NO-TILL	12	21	33	
CROP ROTATION	56	44	100	
PERMANENT SOIL COVER/ MULCHING	7	11	18	
NO-TILL, CROP ROTATION, AND PERMANENT SOIL COVER/MULCHING	16	13	29	0.217 ns
NO-TILL AND CROP ROTATION	25	27	52	
NO-TILL AND PERMANENT SOIL COVER	11	9	20	
PERMANENT SOIL COVER AND CROP ROTATION	11	9	20	
NO COMMENT	24	41	65	
TOTAL	162	175	337	

Research survey, 2023.

Note: *, ** and * mean the coefficient is statistically significant at 1%, 5% and 10%, respectively. Number of observations=337**

The results in Table 5.3 show a statistically significant relationship between education level and the adoption of conservation agriculture practices, with a p-value of 0.025. This suggests that farmers with higher education level could adopt comprehensive conservation agriculture practices, such as no-till, crop rotation, and mulching. Education appears to enhance a farmer's capacity to understand the long-term benefits of conservation agriculture, such as improved soil health, productivity, and resilience against climate impacts.

Table 5.3: Adoption of CA by level of education

Conservation agriculture principles	No formal school	Primary education	Secondary education	Tertiary education	Total	P-value
No-till	4	6	16	7	33	
Crop rotation	11	20	42	27	100	
Permanent soil cover/ mulching	3	2	7	6	18	
No-till, crop rotation, and permanent soil cover/mulching	1	6	12	10	29	0.025**
No-till and crop rotation	6	9	20	17	52	
No-till and permanent soil cover	1	3	7	9	20	
Permanent soil cover and crop rotation	1	3	7	9	20	
No comment	8	20	17	20	65	
Total	35	69	128	105	337	

Research survey, 2023.

Note: *, ** and * mean the coefficient is statistically significant at 1%, 5% and 10%, respectively.**

Table 5.4 indicates a statistically significant relationship between household and the adoption of CA, with a p-value of 0.029. This finding suggests that farmers with diversified income sources, such as those combining farm and non-farm income, are more likely to adopt CA practices, particularly, no-till and crop rotation. Diversified income sources can provide financial stability, allowing farmers to invest in practices that might require initial expenses for equipment, labor, or materials.

Table 5.4: Adoption of CA by the level of household income

Conservation agriculture principles			Total	P-value
	Farm income only	Farm income and none farm income earnings		
No-till	14	19	33	
Crop rotation	56	44	100	
Permanent soil cover/ mulching	8	10	18	
No-till, crop rotation, and permanent soil cover/mulching	16	10	26	
No-till and crop rotation	37	15	52	0.029**
No-till and permanent soil cover	12	5	17	
Permanent soil cover and crop rotation	17	18	35	
No comment	20	5	25	
Total	190	147	337	

Research survey, 2023. Note: *, ** and * mean the coefficient is statistically significant at 1%, 5% and 10%, respectively. Number of observations=337**

Table 5.5 reveals a statistically significant association between farm size and the adoption of conservation agriculture, with a p-value of 0.030. The data suggest that smaller farms, particularly those under 2 hectares, have higher adoption rates for both individual and combined conservation agriculture practices, including no-till, crop rotation, and mulching. This trend may indicate that smaller-scale farmers find conservation agriculture practices more manageable and see the benefits of optimizing limited land resources through sustainable methods. Conservation practices, like crop rotation and mulching can help maintain soil health and productivity, which are especially valuable for small farms that rely on high land productivity to support livelihoods. Smaller farms may also be better suited to implement labor-intensive conservation agriculture practices, as farmers can manage these techniques more effectively on limited acreage.

Table 5.5: Adoption of conservation agriculture by farm size

Conservation agriculture principles	Less than 2ha	More than 2ha but less than 5ha	More than 5ha	Total	P-value
No-till	29	3	1	33	
Crop rotation	90	10	1	101	
Permanent soil cover/ mulching	16	2	0	18	
No-till, crop rotation, and permanent soil cover/mulching	24	4	0	28	0.030**
No-till and crop rotation	46	6	0	52	
No-till and permanent soil cover	17	3	0	20	
Permanent soil cover and crop rotation	17	3	0	20	
No comment	56	7	2	65	
Total	295	38	4	337	

Research survey, 2023.

Note: *, ** and * mean the coefficient is statistically significant at 1%, 5% and 10%, respectively. Number of observations=337**

The results in Table 5.6 show that access to extension services has no statistically significant impact on the adoption of CA, with a p-value of 0.07. Farmers who have access to extension services are notably more likely to adopt multiple conservation agriculture practices, such as no-till, crop rotation, and mulching, indicating that these services provide valuable guidance on implementing sustainable farming techniques. Extension services play a critical role in bridging the knowledge gap for farmers by offering training, practical demonstrations, and ongoing support, which can demystify conservation agriculture practices and make them more accessible.

Table 5.6: Adoption of CA by access to extension services

Conservation agriculture principles	Access to agricultural extension		Total	P-value
	No	**Yes**		
No-till	17	16	33	
Crop rotation	54	46	100	
Permanent soil cover/ mulching	11	7	18	
No-till, crop rotation, and permanent soil cover/mulching	11	18	29	0.07*
No-till and crop rotation	26	26	52	
No-till and permanent soil cover	11	9	20	
Permanent soil cover and crop rotation	9	11	20	
No comment	47	18	65	
Total	186	151	337	

Research survey, 2023.

Note: *, ** and * mean the coefficient is statistically significant at 1%, 5% and 10%, respectively. Number of observations=337**

Table 5.7 indicates a statistically significant relationship between farmers' knowledge of conservation agriculture and their adoption of its practices, with a p-value of 0.001. The result show that farmers with a good understanding of conservation agriculture are significantly more likely to adopt a combination of practices, such as no-till, crop rotation, and mulching, suggesting that knowledge is a key driver in its adoption. This finding highlights the urgency of training programs and information dissemination efforts in raising awareness of the benefits of conservation agriculture, including soil health, water retention, and long-term yield increase.

Table 5.7: Adoption of CA by farmers' knowledge of CA

Conservation agriculture principles	*Farmers' knowledge for conservation agriculture*				*Total*	*P-value*
	None	**Poor**	**Average**	**Good**		
No-till	3	12	6	12	33	
Crop rotation	25	37	19	19	100	
Permanent soil cover/ mulching	5	5	2	6	18	
No-till, crop rotation, and permanent soil cover/mulching	2	4	4	19	29	0.001***
No-till and crop rotation	5	16	10	21	52	
No-till and permanent soil cover	1	6	5	8	20	
Permanent soil cover and crop rotation	2	6	5	7	20	
No comment	31	19	11	4	65	
Total	74	105	62	96	337	

Research survey, 2023.

Note: *, ** and * mean the coefficient is statistically significant at 1%, 5% and 10%, respectively. Number of observations=337**

The result in Table 5.8 reveals that access to conservation agriculture training significantly impacts adoption rates, as indicated by a p-value of 0.036. Farmers who have received training are more inclined to adopt comprehensive conservation agriculture practices, such as combining no-till, crop rotation, and mulching, as compared to those without training. This could be due to interest drawn from the known benefits for both the farmers and the soil as per training information. Trained farmers tend to understand and apply conservation agriculture, more than those that are not trained.

Table 5.8: Adoption of CA by access to CA training

Conservation agriculture principles	Access to conservation agriculture training		Total	P-value
	No	Yes		
No-till	23	10	33	
Crop rotation	75	25	100	
Permanent soil cover/ mulching	17	1	18	
No-till, crop rotation, and permanent soil cover/mulching	16	13	29	
No-till and crop rotation	38	14	52	0.036**
No-till and permanent soil cover	12	8	20	
Permanent soil cover and crop rotation	16	4	20	
No comment	54	11	65	
Total	251	86	337	

Research survey, 2023.

Note: *, ** and * mean the coefficient is statistically significant at 1%, 5% and 10%, respectively. Number of observations=337**

The results on OLR (Table 5.9) indicates the effect of training on the adoption of CA where farmers who received training had 2.17 times higher odds (95% CI: 1.12-4.20) of being in a higher adoption category (partial/full vs. none, or full vs. partial/none) compared to untrained farmers (p=0.022). The report further illustrates the effect of knowledge gradient on the adoption of CA where there is a strong dose-response relationship, each knowledge level increase substantially raises adoption odds, farmers with "very good" knowledge had 12.9 times higher odds (95% CI: 4.3-38.7) of higher adoption versus those with no knowledge (p<0.001). However, the report shows that there is no significant difference between age and adoption level of CA. Similarly, education levels and extension access which didn't significantly predict adoption of CA. The model fit shows that the odds assumption was generally supported (nominal test p>0.05 for most predictors) while significant thresholds indicated clear separation between adoption and categories.

Table 5.9: Ordinal Logistic Regression on adoption of CA

Variable	Estimate	Std. Error	t value	p value	Odds Ratio	CI Lower	CI Upper
Age31 to 40 years	-0.5797	0.6045	-0.9589	0.3376	0.5601	0.1713	1.8317
Age41 to 50 years	-0.7277	0.5766	-1.262	0.2069	0.483	0.156	1.4955
Age51 years and above	-0.8355	0.5197	-1.6076	0.1079	0.4337	0.1566	1.201
Training Yes	0.7736	0.3372	2.294	0.0218	2.1675	1.1192	4.1977
Education Primary	-0.251	0.4826	-0.52	0.603	0.7781	0.3021	2.0036
Education Secondary	0.4083	0.4614	0.885	0.3762	1.5043	0.609	3.7161
Education Tertiary	-0.2927	0.487	-0.6009	0.5479	0.7463	0.2873	1.9384
Knowledge Poor	0.9155	0.35	2.6162	0.0089	2.4981	1.2581	4.9603
Knowledge Average	1.3999	0.4342	3.2244	0.0013	4.0547	1.7314	9.4955
Knowledge Good	2.0806	0.4439	4.6869	0.0	8.009	3.3552	19.1182
Knowledge Very good	2.5555	0.5611	4.5545	0.0	12.8781	4.2878	38.6785
Access to extension	-0.1088	0.2978	-0.3654	0.7148	0.8969	0.5003	1.6079

Research survey, 2023.

5.2 FOCUS-GROUP RESULTS

As shown in Table 5.10, the respondents emphasized that maize is a staple crop produced by smallholders, however, farm yields were affected by climatic conditions which reduced their yields.

As a mitigation strategy, the participants illustrated that they use slash and plant while others hire labor to carry out some tasks on their farms. Some participants indicated that they sometimes lose interest in farming due to challenges like high inputs costs; others revealed that they minimize inputs costs by using manure and compost.

Concerning the limitations under conservation agriculture, the participants highlighted pests, veld fires and conflict of interests on residues which they keep for feeding livestock rather than laying them for mulching. Some have highlighted that they did not have energy demanded for mulching and no-tillage.

The focus-group result suggests that smallholder farmers were practicing CA, although they have encountered some draw backs. Table 5.10 below depicts the results of the focus-group discussions.

Table 5.10: Focus group discussion resul 1

Theme	Sub-themes	Verbatim quotes	Interpretation
Climate variability observations	• Bad weather conditions • Shortage of rainfall & heat wave.	• “I cannot predict weather anymore”. • “I used to know seasons through weather , but not now, everything changed”.	Weather was challenging farmers.
Climatic condition effect on maize production	• Maize is a staple crop. • We plant maize every season.	• “Every household plant maize, even if it is a very small area”. • “I used to produce close to 40 maize bags in my farm”	Maize is a staple crop, but production hampered by climate variability.
Mitigation strategies	• Not to continue • Buy maize • Limit farms • Hire manual labor • Slash & plant without tilling the soil	• “I slash and plant, but the weeds kill my crops” • “I rather buy maize than suffering in the farm” • “I hire eligible farm workers to help tilling by hands”	Conservation agriculture practiced Alternative labour available at a fee
Persistance & Motivation on Conservation agriculture	• High cost of fertilizers • Manure & compost affordable	• “I bought fertilizers yesterday, not affordable anymore”. • “I am using manure fulltime these days’	Minimization of costs High inputs costs
Limitations of conservation agriculture	• Too much workload • Too many principles • Veld fires burn residues	• “I don’t have the energy to mulch and till the whole farm”. • “I am too old to use hand hoe for tilling”. • “I use maize straws to feed my livestock”. • “My farm burned down last season” • “All residues burned during windy seasons”	Farmers are reluctant to practice CA because it is labor-intensive. Veld fire a challenge for farming

Research survey, 2023.

5.3 Discussion

Understanding factors which influence adoption of CA is vital because it informs and directs the intervention, for example, resource allocation and policies from different agricultural development agencies and government. The report in Table 5.1 indicates that there is statistically significant relationship between the age of a farmer and the adoption of conservation agriculture. The findings illustrate that older farmers are more inclined to adopt conservation agriculture practices, most likely due to their accumulated farming experience, increased risk aversion with age, and probably a heightened appreciation for agriculture and sustainable agricultural methods. In contrast, younger farmers lack farming experience and stability.

This result is not in line with the findings by Abera *et al*., (2020) who reported that older farmers in China were less likely to adopt sustainable agricultural methods; similarly, Lim *et al*., (2022) reported that older farmers in Ethiopia may not keep up with the agricultural development technologies. Oduniyi *et al*., (2022) reported that older farmers in South Africa (SA) were less likely to adopt sustainable agricultural technologies. This could be because older farmers in the study area have a better knowledge concerning conservation agriculture. The age of a farmer may not be a barrier towards adoption of conservation agriculture if there is institutional support to provide compatible implements for a particular technology. Institutional support may provide necessary equipment's which farmers may use to practice a new technology and help them sustain their livelihoods.

The results in Table 5.2 shows that there is no statistically significant relationship between gender and the adoption of conservation agriculture practices among smallholder maize farmers in the Vhembe District. This neutrality in conservation agriculture adoption between genders has critical implications. First, it suggests that traditional gender roles, physical labor expectations, or potential disparities in access to resources - factors that often influence agricultural decisions - do not appear to impact the adoption of conservation agriculture practices in a significant way in this study.

Both male and female farmers seem equally likely to adopt or not adopt conservation agriculture practices, which may indicate that adoption decisions are more influenced by other factors. This result contrasts with the findings by Khosa *et al*., (2021) and Khan *et al*., (2022) who reported the significance of gender in the adoption of conservation agriculture in both USA and India due to gender norms which shape women's role in adoption of agricultural technologies. The similarity in the adoption behavior for both male and female farmers could be attributed to many factors, including the levels of returns with conservation agriculture practices.

Furthermore, this finding supports a gender-inclusive approach to outreach and training programs. Since male and female farmers respond similarly to conservation agriculture practices, extension services and conservation agriculture training can be designed and delivered without needing to tailor content specifically for men or women. This could make outreach program design, simpler and more cost-effective, as it allows for unified training efforts. Ensuring that both male and female farmers have equal access to conservation agriculture resources, training, and support could help increase overall adoption rates. Additionally, since both genders are equally open to adopting conservation agriculture practices, reinforcing community-based training that includes both male and female farmers could foster a collaborative learning environment, which may further strengthen conservation agriculture adoption across the district. Comparable adoption behavior across both male and female gender may make a positive contribution on agricultural development policies and resource allocation, due to gender inclusiveness.

The result in Table 5.3 indicated a there is no statistically significant relationship between the adoption of CA and the level of education acquired by the farmer in the Vhembe District. This suggests that educated farmers may also be better equipped with knowledge to assess the advantages of adopting conservation agriculture practices despite initial challenges, such as increased labor or the need for technical knowledge. This finding aligns with previous studies in SA (Kansanga *et al*., 2021 and Ojo *et al*., 2021) where the education of the household head was found to positively and influence the adoption of conservation agriculture. Education enables farmers to process and utilize agricultural innovations more effectively, thereby fostering a willingness to invest in sustainable practices.

This positive association underscores the potential impact of educational interventions in increasing conservation agriculture adoption rates among smallholder farmers. By providing targeted training and accessible information, extension services can bridge the knowledge gap for farmers with lower education levels, helping them understand conservation agriculture benefits and applications. Practical, hands-on training sessions or simplified guides can make conservation agriculture concepts more relatable and actionable, thereby encouraging wider adoption even among less formally educated farmers. Ultimately, strengthening farmers' knowledgebase through education and community training programs is crucial for enhancing conservation agriculture adoption. This may empower farmers to implement sustainable practices that promote productivity and environmental resilience in the Vhembe District and similar regions.

As shown in Table 5.4, the statistically significant relationship found between household income level and the adoption of conservation agriculture could be attributed to financial stability (when a farmer affords to finance the cost which comes with the adoption of a new technology) of the farmers. This positive association between income diversification and CA adoption highlights the need for targeted economic support or incentive programs to assist low-income farmers. Similar findings have been reported in Ghana (Setsoafia *et al*., 2022) and Ethiopia (Negere *et al*., 2022) confirming the significance of income on adoption of smart agricultural technology; findings demonstrate that income makes adoption easier. Financial constraints often limit the ability of low-income households to adopt conservation agriculture practices, as they may be unable to bear any up-front costs or risk short-term reductions in yield during the transition.

Economic security can play a crucial role in agricultural decision-making, as financially stable farmers are more likely to take on the costs associated with sustainable practices that promise longer-term benefits. Providing economic incentives, such as subsidies for conservation agriculture tools or access to microfinance, could make conservation agriculture adoption more feasible for these households. By reducing the economic barriers, policymakers and agricultural extension services could facilitate a broader adoption of conservation agriculture practices across income levels, thus promoting sustainable farming methods that benefit both farm productivity and environmental conservation.

The results in Table 5.5 illustrated a statistically significant association between farm size and the adoption of conservation agriculture. They suggest that the larger farms may face practical challenges in fully adopting conservation agriculture practices, likely, due to the greater time, labor, and resources needed to implement these practices across extensive areas. Similar findings have been reported in SA (Serote *et al*., 2021) and in Ghana (Tama *et al*., 2021) noting that farm size has pervasive influence on adoption. Similarly, a study in SA (Obi and Ayodeyi (2020) reported that farm size and labor influence a range of resources and resource-allocation decisions, including labor.

In the context of Ethiopia, Wordafo *et al*., (2020) concluded that land size and composition affect available labor. Scaling up conservation agriculture practices can require significant investment in machinery (CA compatible planter/ seeding equipment's) or labor, which may deter adoption among large-scale farmers. This suggests a need for tailored support and possibly scaled-assistance programs for larger farms to help overcome these challenges. Providing access to appropriate technology or offering subsidies for equipment could make conservation agriculture practices more accessible for larger farms. Such support would encourage broader adoption across different farm sizes, promoting sustainable farming practices on a larger scale while addressing the unique needs of both small and large farmers.

The findings in Table 5.6 illustrated that access to extension services has no significant impact on the adoption of conservation agriculture. Lack of statistically significance status for extension services suggests that smallholder maize farmers could be facing other adoption hindrances like financial difficulty to fund CA uptake. This result aligns with previous findings from SA (Brown *et al*., 2018) which reported nonstatistical significance of access to agricultural extension services on adoption of CA.

Agricultural extension services often serve as a primary source of information on agricultural innovations, making them essential for effective conservation agriculture adoption**.** By enhancing outreach efforts, particularly in rural and underserved areas, extension programs could reach more farmers who may lack exposure to conservation agriculture benefits and techniques. Increasing the availability and quality of extension services, such as through community-based programs or partnerships with agricultural organizations, could be instrumental in improving conservation agriculture adoption rates. This would allow more farmers to make informed decisions regarding sustainable practices, ultimately contributing to more resilient agricultural systems, environmental conservation efforts while also sustaining livelihoods for smallholder farmers.

As shown in Table 5.7, the farmers' knowledge on conservation agriculture indicates a statistically significant relationship with its adoption, thus, when farmers possess a strong knowledge base, they are better equipped to make informed decisions, weighing the costs and benefits of adopting sustainable practices. Similar findings have been reported in Nigeria (Tokede *et al.,* 2020) indicating that the level of knowledge which a farmer gathers influences the decision to adopt conservation agriculture.

A systematic review (Tama *et al.*, 2021) reported that farmers' knowledge positively influences adoption; similarly, a global study by Kassam *et al.*, (2022) revealed that new knowledge improves performance on conservation agriculture. Enhanced knowledge also reduces uncertainty about the outcomes of conservation agriculture practices, making farmers more confident in implementing them. Consequently, expanding educational initiatives and resources to increase conservation agriculture awareness could play a crucial role in promoting sustainable farming across communities, leading to more widespread adoption and improved agricultural resilience.

As shown in Table 5.9, training and knowledge indicated high odds ratio of being in a higher adoption category as compared to untrained and poor level of knowledge. Training promote knowledge which becomes clear when this effects positively increases the odds of CA adoption. Similar findings have been reported by several studies (Shikuku.,2019; Takahashi *et al.*, 2020; Aswathy and Joseph., 2020; and Marks and Thomas., 2022) where they reported high odds ratio of technology adoption where the respondents have been trained and access knowledge.

5.4 Chapter summary

Determining the factors which influence the adoption of conservation agriculture practices amongst smallholder maize farmers is essential in Vhembe District and elsewhere. Cross-tabulation and Chi-square results indicated that - age of a farmer, household income level, farm size, access to extension services, farmer's knowledge on conservation agriculture and training on conservation were statistically significant in influencing the adoption of conservation agriculture, while gender of a farmer was found to be insignificant in this study.

OLR report revealed that training and knowledge effects have high odds ratio towards the adoption of CA. Factors which influence the adoption of conservation agriculture are essential because they influence the decision of a farmer, either to adopt a technology or dis-adopt. Knowing these factors also assist in establishing the type of intervention needed to support smallholder farmers in accomplishing sustainable livelihoods.

Focus-group discussions' findings indicate that the participants were practicing conservation agriculture minimally. This was attributed to conflict of interest shown with regard to residues which they used to feed their animals instead of using it to mulch. High labour costs were mentioned as a limiting factor to full practice of CA.

CHAPTER 6

ASSESSMENT OF ECONOMIC VIABILITY FOR MAIZE PRODUCTION UNDER CONSERVATION AGRICULTURE PRACTICES

6.0 Chapter introduction

Understanding economic viability of maize production under CA is essential for informed decisions, promote sustainable agricultural practices and the improvement of economic profitability of the participants. This chapter was structured as follows: the presentation of gross margin analysis results, the findings on ranking of maize production input costs under CA, regression of coefficients run to assess the effects of selected socio-economic factors on profitability of maize production and lastly the findings of analysis of variance undertaken to understand the variations in the profitability of maize production under different CA principles.

6.1 Gross Margin analysis results

Figure 6.1: Gross margin analysis for CA maize farmers in Vhembe District

Year	Number of 80kg bags	Unit price per 80kg bag	Total income (R)	Total cost (R)	Gross Margin (R)
1.	27.7	800	22 160	622.15	21 537.85
2.	26.9	800	21 520	766,30	20 753.70
3.	29.8	800	23 840	785.35	23 054.65
4.	27.8	850	23 630	971.42	22 658.58
5.	29.7	850	25 245	928.24	24 316.76

(Research survey, 2023)

Table 6.1 shows the gross margin performance where year 1 had a strong gross margin of R21 537.85, year 2 saw a slight decline to R20 753.70, indicating minor issues in economic profitability, year 3 increased significantly to R23 054.65 likely benefiting from better pricing, year 4 having a declined margin (R22 658.58) despite higher costs, indicating possible efficiency losses and year 5 recorded the highest gross margin of R24 316.76, reflecting better income and cost management.

On the cost trends, the results on table 6.1 shows that the total costs generally increased over the years with specific increases in production inputs. In year 4 saw the highest total costs, which negatively impacted the gross margin, suggesting the need for efficiency improvements. Income from sales illustrate that income fluctuated with the selling price and quantity sold, in year 4 had high income despite reduced sales quantity due to a higher price per maize bag. Year 5 achieved the highest income despite stagnant status in the selling price per bag, likely due to improved volume of production. On pricing and sales volume, the pricing strategy appears to have fluctuated, with significant variations between years, particularly between R800 and R850.

6.2 Ranking of maize production inputs under CA

Table 6.2 Ranking of production inputs under CA maize farming

Production inputs	Year 01	Year 02	Year 03	Year 04	Year 05	Totals
Seeds	103.85	132.43	135.08	172.40	170.05	**713.81**
Labour	79,12	103.05	104.16	149.46	140.67	**576.46**
Fertilizer	133,53	167.68	171.51	195.54	192.87	**861.13**
Weed Control	112.75	133.97	139.26	166.17	151.33	**703.48**
Mulching	74.18	88.13	92.43	118.69	116.02	**489.45**
Pesticides	118,69	141.02	142.89	169.13	157.27	**729.00**

(Research survey, 2023)

On ranking of production inputs for maize production under CA, Fertilizers was ranked on top (R861.13), followed by pesticides at (R729.00) and ranked the lowest was mulching cost at (R489.45). Evaluating the cost structure helps identify which areas can be optimized to improve gross margins further.

6.3 Effect of socio-economic factors on economic profitability of CA maize production.

Table 6.2 findings reveals that the semi-log model achieved the best overall performance based on AIC, BIC, and adjusted R^2, indicating improved explanatory power and model parsimony. In both the semi-log and double-log models, the input variable remained highly significant ($p < 0.001$), affirming its role as a strong predictor of economic profitability. Although the transformations improved model diagnostics, many demographic and institutional variables (e.g., age, education, marital status) remained statistically insignificant, suggesting their limited direct impact on economic profitability within this dataset.

Table 6.2: Regression Coefficients for CA on profitability of maize production

Predictor	Estimate	Std. Error	t value	p-value
(Intercept)	3.542	0.1109	31.93	<.001
Age31 to 40 years	-0.01222	0.07895	-0.155	0.877
Age41 to 50 years	-0.07147	0.07771	-0.92	0.359
Age51 years and above	-0.05973	0.07251	-0.824	0.411
Gender Female	0.05807	0.03399	1.708	0.089
Education Primary	-0.0565	0.06396	-0.883	0.378
Education Secondary	-0.00166	0.06144	-0.027	0.978
Education Tertiary	-0.1216	0.06416	-1.895	0.059
Farming_experience4-6 years	0.00962	0.07171	0.134	0.893
Farming_experience7-10 years	-0.09188	0.07046	-1.304	0.193
Farming_experience11-15 years	-0.01203	0.07798	-0.154	0.878
Farming experience> 15 years	0.04723	0.0669	0.706	0.481
Inputs	-2.186e-05	2.315e-06	-9.442	<.001
Training No	-0.01249	0.04115	-0.304	0.762
Extension No	0.05614	0.03884	1.445	0.149
Knowledge level Poor	0.0106	0.04653	0.228	0.820
Knowledge level Average	0.04207	0.0543	0.775	0.439
Knowledge level Good	-0.0266	0.05125	-0.519	0.604
Rotation Yes	-0.03345	0.03491	-0.958	0.339
Mulch Yes	-0.0111	0.03719	-0.299	0.766
NotillageYes	-0.05743	0.03501	-1.64	0.102

6.4 Analysis of variance of CA on economic profitability

Table 6.3 shows the effect of CA principles on economic profitability of CA maize production. The result indicates that the variable no tillage is a significant predictor of maize economic profitability under CA practice. This shows the farmers not practicing no tillage with a mean yield of 4.5 (on log scale), thus a higher yield compared to those who were practicing no tillage (mean=3.89).

Table 6.3 Analysis of variance on profitability of CA maize production.

Response: Fyield	Df	Sum Sq	Mean Sq	F value	Pr 9)>F
Rotation	1	0.015	0.0152	0.0266	0.870620
Mulching	1	0.470	0.4704	0.8241	0.364639
No tillage	1	5.280	5.2795	9.2497	0.002545**
Rotation: Mulching	1	0.024	0.0238	0.417	0.838391
Crop Rotation: No tillage	1	0.009	0.0093	0.0162	0.898774
Mulching: No tillage	1	0.095	0.3948	0.6918	0.406168
Crop Rotation: Mulching: No tillage	1	0.189	0.1886	0.3304	0.565812
Residuals	329	187.787	0.5708		

Research survey, 2023. Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

6.5 Discussion

Understanding the economic viability of maize production is vital for decision making. Gross margin (GM) results revealed both increased and decreased gross margin for a period under survey (2018-2022). The assessment of gross margins over the five-year period indicates a fluctuating pattern, where in years 1, 3, and 5 showcased a consistent upward trend in gross margins. This increase can be attributed to several factors, including improved agricultural practices, favourable market conditions, or adjustments in input costs. Contrary, years 2 and 4 presented a downturn in gross margins. Potential reasons for this decline could include adverse weather conditions, pest infestations, or increased costs of production inputs. These results underscore the importance of understanding both internal and external factors influencing agricultural profitability. These results are consistent with the findings by Adhikari *et al.*, (2023) who reported different GM in their study area, they attributed different level of economic benefits to yield instability and varying prices. Supporting maize farmers with production inputs have to be needs-oriented rather than one size fits all inputs support which encourage irregular use of production inputs.

Fertilizers play a pivotal role in the agricultural production processes. Their contribution to gross margins is highlighted in the findings, with data indicating that investment in fertilizers correlates positively with yield increases. Similar findings have been reported by Theriault *et al.*, (2018) and Meyo *et al.*, (2020) emphasizing on the expense of fertilizers on maize production. Similarly, Leitner *et al.*, (2020) reported low crop yields following low external inputs (<10kg Nha^{1}) resulting in yield gaps. Moreover, research from recent studies (Smith *et al.*, 2020) indicates that optimal fertilization or proper application of fertilizers leads to enhanced crop yields, which directly impacts gross margins positively in years of increased profitability. Moreover, despite high initial costs, the return on investment from fertilizers (cost-benefit analysis) tends to justify the use of fertilizers, particularly in years marked by favourable market conditions (Johnson & Lee, 2021). Given these insights, CA adopters must consider the strategic application of fertilizers to maximize gross margins.

Analysis of Variance revealed that the correlation between no-tillage practices and economic profitability was significant. The results suggests that no-tillage reduced yield as compared to yield of farmers who were not practicing no-tillage. Contrary, Martin *et al.*, (2022) reported that no-tillage reduced inputs costs, they indicated that no-tillage minimizes the need for fuel and labour, significantly reducing overall production costs. Moreover, Thompson & Alvarez (2023) demonstrates that no-tillage practices contribute to sustainable agriculture, promoting long-term economic profitability and resilience against market fluctuations. Nguyen, (2024) reported analysis of variance (ANOVA) results which demonstrated that no-tillage significantly impacts gross margins, with varying success rates across different crops. Likewise, several previous studies (Thiefelder, 2022; Cusser *et al.*, 2020 and while Wade *et al.*, 2022) emphasized the long-term productivity benefits of no-tillage to the landowners. This finding raises concerns about the long-term sustainability of no-tillage practices in smallholder maize farmers where immediate economic returns are critical for the sustainability of livelihoods by the participants.

6.6 Chapter summary

This chapter presented the gross margin over five-years which revealed fluctuations from year-year shaping the economic profitability. The disparities observed across different years emphasize the need for flexible and adaptive measures. Regression coefficients for economic profitability of maize indicate that input variable highly and significantly predict economic profitability. Fertilizers was found to be the most contributor on costs of production while mulching cost was the lowest expenses on the list. Analysis of variance of CA principles on economic profitability revealed that no-tillage was a factor of economic profitability, thus, those farmers who were not practicing no tillage had a higher yield compared to those who were practicing no tillage. Lower yields could directly impact the economic profitability of maize production, resulting in decreased income for smallholder farmers.

CHAPTER 7

SUMMARY, CONCLUSION, RECOMMENDATIONS AND AREAS FOR FURTHER STUDIES

7.0 Chapter introduction

This chapter presents summary, conclusion, recommendations which entails the presentation of a proposed framework for sustainable and viable CA practices and lastly areas for further study. The aim of the study was to analyse the adoption of conservation agriculture and its impact on livelihoods of participating smallholder maize farmers in Vhembe District Municipality.

7.1 Summary for the objectives of the study

7.1.1 Summary for Objective 1

Objective one investigates the characterization of smallholder maize farmers under CA, emphasizing demographic attributes and the adoption of CA among smallholder maize farmers. The characterization of smallholder maize farmers reveals key insights. A significant proportion of this study were female farmers. Female dominance in agriculture could be attributed to proximity to residential area where females find it easy to access the farms without worrying about transport cost since unlike mines, rural farms are in residential areas. Prior studies in Kenya (Nyang' au *et al*., 2021) and Malawi, (Chinseu *et al*., 2019) have reported similar findings where women dominated participants in their studies. Gender dynamics may impact CA practices, resource access, and decision-making processes.

Majority of the participant were aged 50 years and above. This could be attributed to high unemployment rate where alternatively, agriculture become their economic reliance. Similar findings of less participation in agriculture by youth have been reported in Nigeria, (Osabohien *et al*., 2022). The aging population may also indicate a potential future challenge for succession and sustainability on maize production, as younger generations may not be fully engaged in CA farming practices.

More than half of the participants indicated that they adopted CA partially. Partial adoption of CA could be explained by lack of training on CA and poor knowledge which is a powerhouse for proper performance. The findings are consistent with prior studies (Tama *et al*., 2021) where it was found that knowledge correlated with the adoption of CA. The partial adoption of CA suggests that while smallholder maize farmers recognize its potential benefits (such as improved soil health and increased resilience to climate change), barriers on CA adoption still exists.

On factors influencing the adoption of CA, training was significantly associated with the adoption of CA, moreover, training and knowledge of participants have higher odds ratio of adopting CA as compared to untrained farmers. This could be attributed to the ability to understand after being offered training. Similar result has been reported in by Prokopy *et al*., (2019) and Ruzzante *et al*., (2021) who concluded that formal training may likely correlate with the adoption of CA. This finding underscores the importance of structured training programs in facilitating the adoption of CA.

7.1.2 Summary for Objective 2

The second objective was to investigate factors which influence the adoption of CA in Vhembe District. Cross-tabulation findings indicates that age emerged as a highly significant factor influencing CA adoption, with a p-value of 0.001. This finding suggests that older farmers are more likely to adopt CA, possibly due to accumulated knowledge and experiences gathered during agricultural practices. Lastly, training was significantly associated with CA adoption ($p = 0.036$), underscoring the importance of structured training programs in facilitating the adoption of CA. Nevertheless, statistically there was no relationship between gender, access to extension services and the adoption of CA.

On further investigating the factors which influenced the adoption of CA, OLR findings indicates the effect of training on the adoption of CA where farmers who received training had 2.17 times higher odds (95% CI: 1.12-4.20) of being in a higher adoption category (partial/full vs. none, or full vs. partial/none) compared to untrained farmers ($p=0.022$). The results further illustrate the effect of knowledge gradient on the adoption of CA where there is a strong dose-response relationship, each knowledge level increase substantially raises adoption odds, farmers with "very good" knowledge had 12.9 times higher odds (95% CI: 4.3-38.7) of higher adoption versus those with no knowledge ($p<0.001$).

7.1.3 Summary for Objective 3

The third objective was to investigate the economic viability of smallholder maize production under CA. GM results revealed positive gross margin for a period under survey (2018-2022), however, there was some fluctuations reflected by the decrease and increase of GM. The instability of GM could be attributed to attained yield visas the price of maize at the time. These finding is consistent with the findings by Adhikari et al., (2023) who reported different GM in their study area, they attributed different level of economic benefits to yield instability and varying prices. GM further indicated that fertilizers were main contributors on the costs of production. Moreover, MLR findings shows that the input variable remained highly significant ($p < 0.001$). This could be attributed to production efficiency on maize production. This finding concurs with Adegbite *et al*., (2023) who reported that increased use of inorganic fertilizers in SSA to enable a great increase of crop yield, as such, this might influence profitability of farmers.

Furthermore, the input variable remained highly significant ($p < 0.001$), affirming its role as a strong predictor of profit. Although the transformations improved model diagnostics, many demographic and institutional variables (e.g., age and level of education) remained statistically insignificant, suggesting their limited direct impact on profit within this dataset. Lastly, analysis of variance results for the profitability of CA maize production where it revealed that the variable no tillage is a significant predictor of maize profit under CA practice. The result shows that farmers not practicing no tillage with a mean yield of 4.5 (on log scale) had a higher yield compared to those who were practicing no tillage (mean=3.89).

7.2 Conclusion

Understanding the vital of demographic factors in adoption of agricultural technologies could assist in addressing their unique needs. Interventions that acknowledge gender dynamics could address the relevant targets for agricultural development. For example, targeting support programs, training and resources towards older female farmers can be an effective strategy for promoting the adoption of CA. The aging population may also indicate a potential need for attraction of younger agrarians to address future succession plan needs on maize farming. Focusing on the specific needs of female farmers and older adults, such as easier access to CA farming implements or peer support networks, could lead to more comprehensive adoption of sustainable practices.

The findings highlighted the pivotal role played by age, training and knowledge on influencing the adoption of CA. This suggests that effective, structured and tailored programs tailored to specific CA needs and contexts are vital for knowledge dissemination. Ongoing support and continuous learning may serve as a powerhouse for decision-making concerning CA adoption. This fluctuations in gross margin indicates that while there is potential for profitability, there are specific years where external factors or market dynamics may have negatively impacted economic performance. Fertilizers emerged as a significant contributor to economic production inputs, highlighting their importance in enhancing crop yields and overall profitability. The data suggests that appropriate fertilizer application in the years showing increased gross margins correlates with improved agricultural outcomes.

The analysis indicates that variable inputs negatively affect economic profitability. This suggests a misalignment between the costs of these inputs and the economic returns generated from their use. Farmers may need to reassess their strategies for input allocation to optimize profitability while minimizing costs.

Lastly, the analysis of variance indicates that no-tillage practices negatively influence economic profitability. This finding calls into question the effectiveness of no-tillage as a stand-alone practice for enhancing economic outcomes in the maize production under CA. A carefully balanced approach is vital to enhance financial sustainability in CA practices. This thesis provides valuable insights into the complex interactions between CA practices, economic inputs, and profitability, offering a foundation for improved decision-making in the pursuit of sustainable and economically viable maize farming under CA.

7.3 Recommendations

This study therefore makes the following recommendations:

(1) The collaboration of agricultural developers in promoting widespread adoption of sustainable agricultural innovations and practices. This collaboration can establish a platform for farmers to provide feedback on new practices, enabling continuous improvement and adaptation of technologies to local conditions. Agricultural developers can coordinate training programs and workshops for knowledge sharing, and capacity building.

(2) The promotion of collaborative research. This relationship can also establish a joint research initiative between farmers, and higher learning institutions to develop tailored solutions, access to resources and technology together with financial services to help farmers invest in significant technologies.

(3) Community engagement approach to sustainable agricultural development. This approach can promote cultural and community involvement in ensuring the tailormade design and implementation of local sustainable agricultural practices, thereby sustaining the environment and ensuring sustainable livelihoods for smallholder maize farmers.

(4) Advocacy for policies that support sustainable agricultural practices while also ensuring fair prices for inputs, craft policies that provide incentives, and prolonged support for smallholder maize farmers in transition to sustainable agricultural practices.

(5) The adoption of proposed framework for sustainable and economically viable CA.

7.4 Proposed framework for sustainable and economic viable CA

The following is the proposed framework for a sustainable and economically viable CA for smallholder maize farmers in the study area and the world. The model proposes the collaboration of key agricultural stakeholders, this includes smallholder farmers, agricultural extension workers, local governments, NGOs, agricultural research institutions, and private sector actors. The role of the collaboration amongst others will be to foster knowledge sharing, resource pooling, and the creation of supportive policies that promote CA practices tailored to local needs. Policy Framework for Conservation Agriculture will develop and CA compatible support policies. Thus, developing policies that incentivize the adoption of CA practices, ensuring they are aligned with sustainable agricultural goals. Policy support may also ensure regulations favouring the use of sustainable practices and provide subsidies or financial assistance for adopting CA.

The collaboration may also provide capacity building through training programs, organize workshops and training sessions to educate farmers about CA techniques, benefits, and sustainable farming practices. Skill Development may enhance farmers' skills in using CA-compatible implements, tools and methods, leading to increased productivity. Moreover, the collaboration may support smallholder maize farmers through purchasing CA-Compatible Implements, access to tools and also facilitate access to affordable, high-quality implements that support CA, such as no-till planters and weeders.

The collaboration may provide financial Support through the introduction of financial mechanisms or subsidies to help farmers purchase these implements. CA may be promoted through information and awareness programs, for example, hosting information days and farmers' days where successful CA practices are shared. To stimulate smallholder maize farmers, CA annual competitions and demonstration competitions can encourage farmers to adopt innovative practices and showcase their successes, fostering a community of learning. To address economic efficiency on CA, CA products may be market-oriented, thus ensuring that smallholder farmers have access to markets for their produce, promoting CA as a method that can lead to higher-quality yields. Lastly, CA must be value-chain integration, thus, the collaboration must link smallholder farmers with buyers, processors, and retailers to enhance the economic viability of CA.

Through this collaboration, smallholder maize farmers may benefit improved soil health (CA practices, such as minimal soil disturbance, cover cropping, and crop rotation, enhance soil fertility and structure, leading to better yields over time). Through CA practices, farmers may gain increased crop resilience, thus, the diverse practices in CA improve resilience against climate change, pests, and diseases, safeguarding farmers against unexpected losses. Moreover, through the suggested framework, farmers may benefit enhanced maize productivity, thus, with better soil health and access to suitable implements and tools, farmers can experience higher maize yields, thus improving their income and livelihood enhancement. Moreover, farmers may have access to potential information and resources, capacity building and awareness programs provide farmers with critical information that helps them make informed decisions. Moreover, this collaboration may strengthen community ties where efforts foster a sense of community among farmers, promote community and stakeholder engagements while enhancing collective action for mutual benefits, such as shared resources and information. Lastly, by adopting CA and linking with market-oriented practices, farmers can secure better prices for their products, contributing to improved livelihoods.

The proposed framework emphasizes collaboration, capacity building, and market orientation, aligning various stakeholders to support smallholder maize farmers in adopting sustainable practices. The benefits, ranging from improved soil health to increased income, make a compelling case for implementing such an integrated approach to agricultural development, particularly for vulnerable smallholder maize farmers.

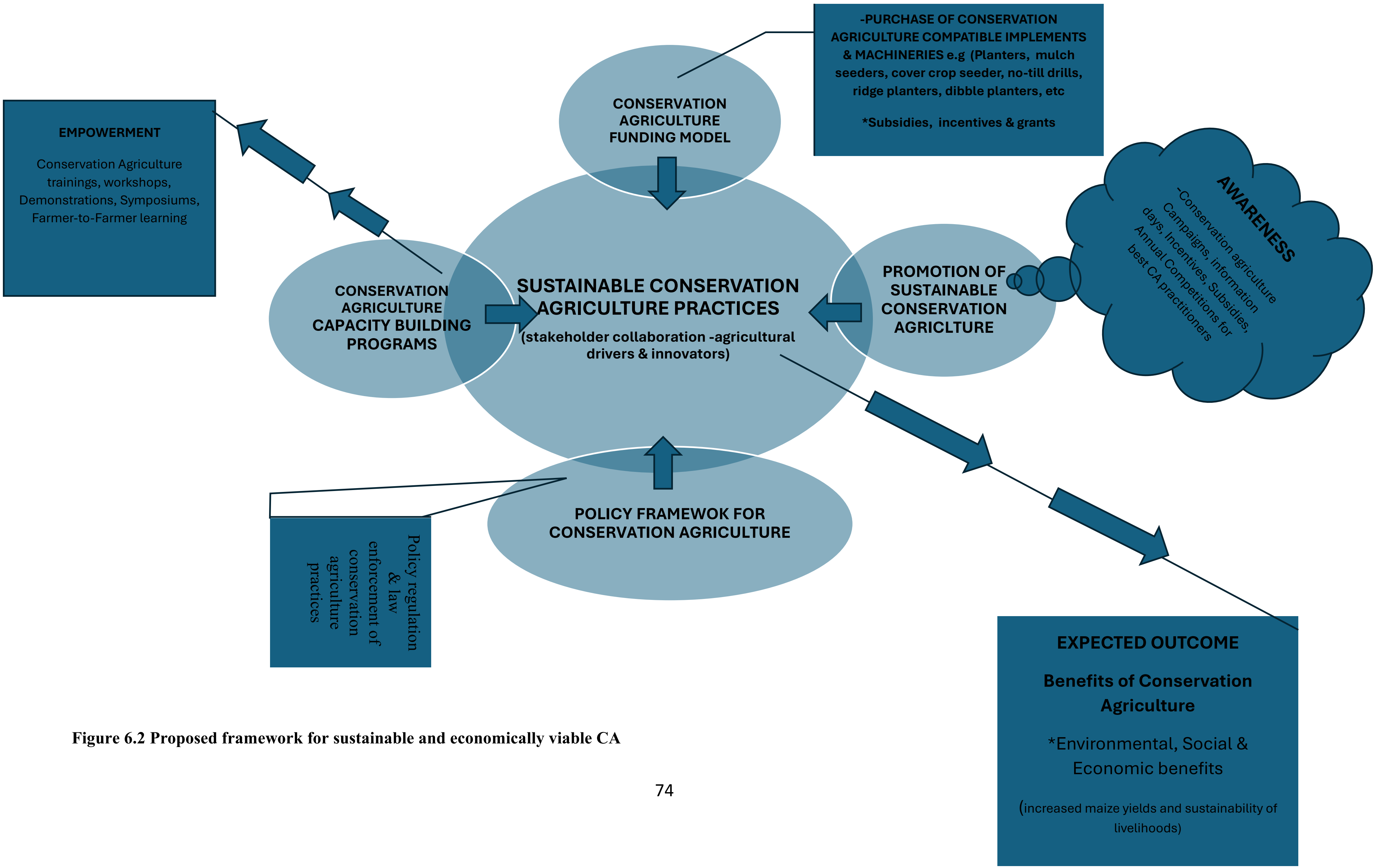

Figure 6.2 Proposed framework for sustainable and economically viable CA

7.5 Areas for further study

(1)There is need for a comprehensive study to test the applicability of the suggested CA framework.

(2) There is a need for a prolonged experimental study to explore the long-term economic and environmental benefits of CA under smallholder maize farming.

(3) There is a need for further research and development of a comparative study between CA and conventional farming methods focusing on both economic viability and environmental benefits of both production methods on smallholder maize production.

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9. APPENDICES

9.1 Appendices 1: Ethical Clearance Certificate

ETHICS APPROVAL CERTIFICATE

ETHICS APPROVAL CERTIFICATE

**FACULTY OF SCIENCE, ENGINEERING AND AGRICULTURE
RESEARCH ETHICS COMMITTEE**

NAME OF RESEARCHER/INVESTIGATOR: Mulaudzi RG

STAFF/ STUDENT NO: 9317295

PROJECT TITLE: Analysis Of The Adoption Of Conservation Agriculture And Impact On Livelihoods For Participating Smallholder Farmers In Vhembe District

ETHICAL CLEARENCE NO: FSEA/22/IRD/14/1707

SUPERVISORS/ CO-RESEARCHERS/ CO-INVESTIGATORS

NAME	INSTITUTION & DEPARTMENT	ROLE
Dr. J Zuwarimwe	University of Venda, Institute for Rural Development	Supervisor
Dr. A M Mathaulula	University of Venda, Institute for Rural Development	Co-supervisor

Type: **Student research**

Risk: **Minimal risk to humans, animals, or environment (Category 1)**

Approval Period: **November 2022-January 2025**

The Faculty Research Ethics Committee (FREC) of the Faculty of Science, Engineering and Agriculture hereby approves your project as indicated above.

General Conditions
While this ethics approval is subject to all declarations, undertakings and agreements incorporated and signed in the application form, please note the following.

University of Venda

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9.2 Appendices 2: Focus Group Discussion Guideline

FOCUS-GROUP DISCUSSION GUIDELINE

Topic: Analysis of the adoption of conservation agriculture and impact on livelihoods for participating smallholder farmers in the Vhembe District

(1) What is the climate variability you have observed?

(2) What is the effect of climatic conditions on maize production?

(3) What are some mitigation strategies?

(4) What are the advantages to conservation agriculture practices?

(5) What are the limitations of conservation agriculture practices?

9.3 Appendice 3: Questionnaire

RESEARCH INSTRUMENT **QUESTIONNAIRE NUMBER: ----------**

RESEARCH QUESTIONNAIRE PROJECT NUMBER: FSEA/22/IRD/14

TITLE: ANALYSIS OF THE ADOPTION OF CONSERVATION AGRICULTURE AND IMPACT ON LIVELIHOODS FOR PARTICIPATION SMALLHOLDER FARMERS IN VHEMBE DISTRICT

This questionnaire is designed to collect farmers' biographical data, conservation agriculture practices and the profit margin for maize production. These data will only be used to analyse the adoption of Conservation Agriculture and its impact on the livelihoods for the participating smallholder farmers in the Vhembe District Municipality (Makhado, Musina, Thulamela and Collins Chabane). Dissemination of the results for this analysis will be done through organized meetings with the participants and other interested parties.

THE STRUCTURE OF THIS QUESTIONNAIRE:

This questionnaire is composed of seven (8) pages with six (6) sections as outlined below:

Section A - Biographical details of the respondent.
Section B - Farm status.
Section C - Knowledge of climate change and variability.
SECTION D - Conservation Agriculture knowledge.
Section E - Financial report on maize production.
Section F - Diversification and sustainability of livelihoods.

Note that participation is voluntary, and there is no remuneration for participation.

Participant may use any language to express their views.

NB: Kindly answer all the questions in this questionnaire.

Enumerator: -- Date: ---------------

SECTION A: BIOGRAPHICAL DETAILS OF THE RESPONDENT

1.	**Age of the respondent.**	**Put a cross (x)**
1.1	Less than 21 years	1
1.2	22 to 30 years	2
1.3	31 to 40 years	3
1.4	41 to 50 years	4
1.5	51 years and above	5

2.	**Gender of the respondent.**	**Put a cross (x)**
2.1	Male	1
2.2	Female	2
2.3	If other, please specify……………………………………………..	3

3.	**Marital status of the respondent.**	**Put a cross (x)**
3.1	Married	1
3.2	Not married	2
3.3	Divorced	3
3.4	Widow/ Widower	4

4.	**What is the household size of your family?**	**Put a cross (x)**
4.1.	1-2	1
4.2.	3-4	2
4.3.	5-6	3
4.4.	7-8	4
4.5.	9-10	5
4.6.	Other, please specify…………………………………………………..	6

5.	**What is your highest level of education**	**Put a cross (x)**
5.1.	No schooling	1
5.2.	Primary education	2
5.3.	Secondary education	3
5.4	Tertiary education	4

6.	**Source of income for the household head.**	**Put a cross (x)**
5.1.	Farming fulltime	1
5.2.	Working part-time	2
5.3.	Unemployed	3
5.4.	Student (at school or further education)	4
5.5.	Other, please specify…………………………………………………	5

7.	**How long have you been farming?**	**Put a cross (x)**
7.1.	1-3 years	1
7.2.	4-6 years	2
7.3.	7-10 years	3
7.4	11-15 years	4
7.5.	> 15 years	5

8	**Have you received any agricultural training?**	**Put a cross (x)**

8.1	Yes	**1**
8.2	No	**2**

9	**Do you receive agricultural extension services?**	**Put a cross (x)**
9.1	Yes	**1**
9.2	No	**2**

SECTION B: FARM STATUS

10.	**What is the farm ownership status?**	**Put a cross (x)**
10.1	Permission to occupy (PTO)	**1**
10.2	Deed of Grant	**2**
10.3	Communal land	**3**
10.4	Family owned	**4**
10.5	Other, please specify………………………………………………….	**5**

11.	**What are the types crops you plant in the farm?**	**Put a cross (x)**	**Size of land planted**
11.1	Maize	**1**	
11.2	Vegetables	**2**	
11.3	Fruit trees	**3**	
11.4	Other, please specify………………………………………………….	**4**	

12.	**What is the size of the farm in hectares(ha)?**	**Put a cross (x)**	**Put a specific size**
12.1	Less than (<) 1 ha	**1**	
12.2	Above 1 less than 2 ha	**2**	
12.3	Between 3 & 5 ha	**3**	
12.4	Between 5 & 10 ha	**4**	
12.5	Greater than (>) 10 ha	**5**	

13. A	**What is the size of farm used for maize production (hectares- ha)?**	**Put a cross (x)**	**Put a specific size**
13.1	Less than (<) 1 ha	**1**	
13.2**.**	Above 1 less than 2 ha	**2**	
13.3**2**	Between 3 & 5 ha	**3**	
13.4	Between 5 & 10 ha	**4**	
13.5**.4**	Greater than (>) 10 ha	**5**	
13.B	Do you have any unused space in your farm?	**Yes / No**	**Size :_________**

14.	**What is the number of employees on the farm?**	**Put a cross (x)**
14.1	None	**1**
14.2**.**	Less than (<) 5 fulltime workers	**2**
14.3**2**	More than (>) 5 fulltime worker	**3**
14.4	Less than (<) 5 casual (seasonal/ part-time) workers	**4**
14.5**.4**	More than (>) 5 casual (seasonal/ part-time) workers	**5**

SECTION C: RESPONDENTS' KNOWLEDGE ON CLIMATE CHANGE AND CLIMATE VARIABILITY

15	Rate your experience with climate change & variability	Put a cross (x)
15.1	None	1
15.2	Poor	2
15.3	Average	3
15.4	Extremely	4
15.5	Alarming	5

16.	Do you receive any information on climate change & variability from your agricultural advisor?	Put a cross (x)
16.1.	Yes	1
16.2.	No	2

17.	Have you been trained in climate change mitigation strategies?	Put a cross (x)
1.1.	Yes	1
1.2.	No	2

18.	What are the changes in climate that you have observed?	Put a cross (x)
18.1.	Increase temperature	1
18.2.	Decrease temperature	2
18.3.	High rainfall (floods)	3
18.4	Low rainfall (droughts)	4
18.5	No observation	5

19.	Do you change farming methods as mitigation strategies to climate change & climate variability?	Put a cross (x)
19.1.	Use climate smart – technologies/methods of farming	1
19.2.	Use conventional /traditional methods of farming	2
19.3.	Use the usual methods of farming	3
19.4.	Abandon farming	4

SECTION D. KNOWLEDGE AND PRACTICE OF CONSERVATION AGRICULTURE PRINCIPLES

20.	Rate your knowledge of Conservation Agriculture (CA)	Put a cross (x)
20.1	None	1
20.2	Poor	2
20.3	Average	3
20.4	Good	4
20.5	Very good	5

21. A	How long have you been practicing Conservation Agriculture (CA)?	Put a cross (x)
21.1.	Less than 5 years	1
21.2.	More than 5 years	2

21. B	Have you ever dis-adapted / abandon Conservation Agriculture (CA)?	Yes/ no
21.C.		
21.D	If yes, why…….	

22.	Which of the CA principles are your practicing?	Put a cross (x)

22.1	**No-till**	**1**
22.2	No – till & Crop-rotation	**2**
22.3	No-till & permanent soil cover/ mulching	**3**
22.4	**Crop-rotation**	**4**
22.5	Crop rotation & No-till	**5**
22.6	Crop rotation & Permanent soil cover / mulching	**6**
22.7	**Permanent soil cover/ Mulching**	**7**
22.8	Permanent soil cover/ Mulching & no- till	**8**
22.9	**No-till, Permanent soil cover/ Mulching & crop rotation**	**9**
22.10	**None – of the above**	**10**

23. TRAINING ON CONSERVATION AGRICULTURE

Which of the following principles of CA have you been trained on?	**Put a cross (x)**
No-till	**1**
No – till & Crop-rotation	**2**
No-till & permanent soil cover/ mulching	**3**
Crop-rotation	**4**
Crop rotation & No-till	**5**
Crop rotation & Permanent soil cover / mulching	**6**
Permanent soil cover/ Mulching	**7**
Permanent soil cover/ Mulching & no- till	**8**
No-till, Permanent soil cover/ Mulching & crop rotation	**9**
None – of the above	**10**

SECTION E. FINANCIAL RECORDS FOR MAIZE PRODUCTION

24.A MAIZE ENTERPRICE BUDGET (Inputs cost per annum)						
Inputs	**Year 1 (2018)**	**Year 2 (2019)**	**Year 3 (2020)**	**Year 4 (2021)**	**Year 5 (2022)**	**Total**
1.Seeds						
2. Labour						
3. Soil preparation						
4. Planting						
5. Weeding						
6. Mulching						
7. Harvesting						
8. Packaging						
9. Pesticides						
10. Fertilizers						
11.Packaging						
12Transport						
8. Other						
9. Other						
OVERALL TOTAL						

25. MAIZE YIELD PER 80Kg BAG

YIELD / OUTPUTS	Year 1 (2018)	Year 2 (2019)	Year 3 (2020)	Year 4 (2021)	Year 5 (2022)	Total
SIZE OF LAND PLANTED MAIZE						
NUMBER OF BAGS HARVESTED & SOLD (80kg) PER YEAR						
NUMBER OF BAGS HARVESTED AND CONSUMED PER YEAR						
TOTAL NUMBER OF BAGS HARVESTED, SOLD AND CONSUMED PER YEAR						

29. C What is your source of inputs? (tick)

Supplier	Support / own purchase	Tick	Type of support received (Kindly specify)
Government	Farmers' Support		
Government	Conservation Agriculture support		
Government	PESI		
Own seed bank	Saved seed from own field		
Gift	Received from another farmer		
Buy by yourself	**Own purchase**		
Other			

SECTION F. 1. DIVERSITY & SUSTAINABILITY OF LIVELIHOODS

30.	What are your main livelihood strategies?	Put a cross (x)
30.1.	Farming	1
30.2.	Other, please specify...	2

HA KHENSA……… RI YA LIVHUWA …… THANK YOU…..