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**THE EFFECTS OF CONSERVATION AGRICULTURE UNDER RAIN FED
CONDITIONS IN CHIMANIMANI DISTRICT**

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APPROVAL FORM
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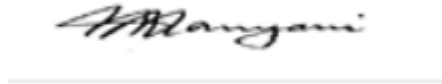


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DECLARATION

I declare that this dissertation is the product of my own work and that it has not been submitted before for any degree or examination in any other university, and that all the sources I have used or quoted have been indicated and acknowledged as complete references.

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DEDICATION

I dedicate this dissertation to God, my lovely wife Melissa and son Atipaishe Karinda.

ACKNOWLEDGEMENTS

I would like to acknowledge the assistance I received from my supervisor Dr. Siziba, his unwavering support and mentorship made this research a success. I also acknowledge support and assistance of my research participants. Above all, I give many thanks to the almighty God, for with him all things are possible.

ABSTRACT

The abstract of this research aims to provide a comprehensive analysis of the effects of conservation agriculture (CA) under rain-fed conditions in the Chimanimani District. This study investigates the impact of CA practices on soil health, crop yields, and socio-economic outcomes within the context of sustainable agriculture and agroecology theories. Utilizing both qualitative and quantitative research methodologies, the study employs thematic analysis to quantify the effects of CA while controlling for confounding variables. The research adheres to established protocols and standards in data collection and analysis as outlined by the Food and Agriculture Organization (FAO) and the Conservation Agriculture Network for Africa (CANA), ensuring methodological rigor and enhancing the reliability of the findings. Key assumptions include the willingness and ability of local farmers to adopt CA practices with adequate support, and the representativeness of the selected sample of respondents. Limitations such as the generalizability of findings to other regions and the logistical challenges posed by the rural setting are acknowledged. The study highlights the potential of CA to improve soil health, enhance crop productivity, and support sustainable farming practices, contributing valuable insights for policymakers, researchers, and local inhabitants in the field of climate change and sustainable development.

KEYWORDS: Conservation Agriculture, Rain Fed Conditions, Chimanimani District

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ACRONYMS

| | |
|------|---|
| CA | Conservation Agriculture |
| CANA | Conservation Agriculture Networks of Africa |
| FAO | Food and Agriculture Organisation |
| SPSS | Statistical Packages for Social Sciences |

CHAPTER 1: INTRODUCTION TO THE STUDY

1.1 Introduction

Conservation agriculture (CA) has emerged as a promising sustainable farming approach designed to address soil degradation, water scarcity, and the vulnerability of traditional farming systems to climate variability, especially under rain-fed conditions prevalent in regions like Chimanimani District, Zimbabwe. Defined by principles of minimal soil disturbance, permanent soil cover, and crop rotation, CA offers the potential to improve soil health, enhance crop productivity, and support resilient livelihoods for smallholder farmers in resource-constrained settings. In Chimanimani, where agriculture is heavily impacted by soil erosion, nutrient depletion, and irregular rainfall, CA was introduced as a strategic response to improve agricultural outcomes. However, its effectiveness and adoption remain uncertain, influenced by various environmental and socio-economic factors, as well as policy support. This study explores CA's impact on soil health, crop yields, and socio-economic resilience, while assessing socio-economic and policy barriers to its adoption, with the goal of providing targeted recommendations that could enhance food security and sustainability in rain-fed agricultural systems like Chimanimani.

1.2 Background to the study

Globally, a range of agronomic factors have been reported to have an impact on the performance of conservation agriculture and often determine its performance (Mupangwa et al., 2014). Conservation agriculture takes advantage of natural ecological processes to conserve moisture, enhance soil fertility, and improve texture and structure of the soil. This sustainable farming method is based on the three principles of crop diversification, minimum soil disturbances and permanent soil cover (Donovan, 2020). It helps farmers to maintain and boost yields and increase profits, while reversing land degradation, protecting the environment, and responding to growing challenges of climate change. It highlights the fact that by simply farming at a higher standard it is possible to feed a family from a very small area of land. Conservation agriculture was coined in the 1990s, but the idea to minimise soil disturbance has its origins in the 1930s during the Dust Bowl in the United States of America, Donovan (2020). In 1980s conservation agriculture technique was also used in agronomy in Latin America and South Asia. CA has been increasingly adopted worldwide, particularly in regions facing challenges such as soil degradation, water scarcity, and climate variability (Kassam et al., 2015).

In the early 2000s conservation agriculture was introduced to Africa and its principles were incorporated into major projects in Africa and South Asia (Donovan, 2020). In Africa 33% of smallholder farmers are undernourished, (FAO, 2020). Over the last decade, food security and income for many small holder farmers in sub-Saharan Africa have declined significantly (Giller, 2020). Several African countries have embraced CA as a sustainable farming approach, with notable success stories in countries like Zambia, Malawi, and Kenya (Marambanyika, 2022). In regions with recurrent droughts and soil degradation, CA in these countries has helped improve food security, enhance resilience to climate change, and reduce vulnerability among smallholder farmers.

In Zimbabwe the national yield is cited at around 0.84 metric tonnes per hectare against a projection of 1.47 metric tonnes per hectare (Rugwete et al., 2023). This means that many farmers are not able to sustain themselves from the land that they are utilising, even though they spend many hours tilling and working the land. Most of the seed and fertilizer utilised is managed so inefficiently that it does not produce a viable return (Thierfelder & Wall, 2019). Zimbabwe adopted conservation agriculture in 2004 through the government as an adaptation strategy to climate change and to promote community resilience and sustainable development.

Chimanimani District, located in the eastern highlands of Zimbabwe, is characterized by its rugged terrain and diverse agricultural landscape (Musarandega & Chingombe, 2020). Historically, farmers in the region have relied on conventional farming methods, including tillage-based practices, which can lead to soil degradation, erosion, and decreased productivity, particularly in rain-fed environments. Farmers using conventional methods are faced with challenges including deterioration in yield, emanating from soil acidity, soil erosion, compaction of the soil to mention but just a few. The adoption of conservation agriculture principles, such as minimum soil disturbance, permanent soil cover, and crop rotation, has gained momentum as a sustainable alternative to conventional agriculture (Ncube, 2021). However, the extent to which CA practices can improve agricultural outcomes in Chimanimani District remains to be fully understood.

1.3 Statement of the problem

Farming in Chimanimani district has been marred with poor yields attributed to soil capping, soil erosion, acidity of the soil and sporadic rainfall patterns (Ncube, 2021). The adoption of conservation agriculture in Chimanimani District, Zimbabwe, was implemented as a strategy by

the government to promote rural transformation and sustainable development (Mutandwa, Hanyani-Mlambo & Manzvera, 2019). Despite efforts to improve livelihoods through conservation agriculture, rural communities in Chimanimani District continue to face persistent poverty and food insecurity (Musarandega, Chingombe & Pillay, 2020). Additionally, the suitability of CA practices under the district's specific agroecological and climatic conditions is not well documented. Addressing these challenges requires a thorough understanding of the effects of CA on soil health, crop yields, and socio-economic outcomes in rain-fed environments.

1.4 Aim

The aim of this study is to establish the effects of conservation agriculture under rain-fed conditions in Chimanimani District.

1.5 Research Objectives

1.5.1 Main Research Objective

The main objective of this study is to establish the effects of conservation agriculture as an adaptation strategy to climate induced droughts on food crop production efficiency in Chimanimani district.

1.5.2 Sub Research Objectives

- To establish the impact of conservation agriculture practices on soil health indicators.
- To establish the effects of conservation agriculture on crop yields and agricultural productivity in rain-fed farming systems.
- To analyze the socio-economic factors influencing the adoption and implementation of conservation agriculture practices among farmers in Chimanimani District.
- To establish the policy implications and recommendations for promoting sustainable agriculture and enhancing food security in the region.

1.6 Research Questions

1.6.1 Main Research Question

The main research question of this study is to assess the effects of conservation agriculture as an adaptation strategy to climate induced droughts on food crop production efficiency in Chimanimani district.

1.6.2 Sub Research Questions

- What are the effects of conservation agriculture practices on soil health indicators?

- What are the effects of conservation agriculture on crop yields and agricultural productivity in rain-fed farming systems?
- What socio-economic factors influence the adoption and implementation of conservation agriculture practices among farmers in Chimanimani District?
- What are the policy implications for promoting sustainable agriculture and enhancing food security in the region?

1.7 Justification or Significance of the Study

The study is significant for several reasons. Firstly, it contributes to the growing body of literature on conservation agriculture and its applicability in rain-fed environments, particularly in sub-Saharan Africa. Secondly, the findings will provide valuable insights for policymakers, agricultural extension services, and development practitioners seeking to promote sustainable agriculture and improve rural livelihoods in Chimanimani District and similar regions. Lastly, the study has practical implications for farmers, helping them make informed decisions about adopting conservation agriculture practices to enhance their livelihoods and resilience to climate change and variability.

1.7.1 Government Policy Makers

The success of this study will benefit policy makers by bringing truthful information gathered from selected communities on conservation agriculture. Gathering primary data from the area will provide policy makers with useful information that informs strategies aimed at improving rural livelihoods in Zimbabwe. The study results will also contribute to the voice of scholars in providing information to the government on the role of conservation agriculture in promoting sustainable rural livelihood, resilience, and improved food crop production in Zimbabwe in general and Chimanimani District in particular. Policy maker and the government will be able to make informed decisions in policies relating to improving the livelihoods of the people living in rural areas. In addition, insights from the study might be useful for the nation's budget allocations, formulation of research and technological advancement in support of conservation agriculture in Zimbabwe.

1.7.2 Researcher and Academia

The study is going to be useful to researcher as they gain experience through this study. The success of the study will play a fundamental role in ensuring that the student fulfils the requirements of the course, master's degree in Climate change and Sustainable Development,

which would enable him to graduate from the country's leading tertiary institution, **Bindura University of Science Education**. The research findings will contribute to the growing knowledge on conservation agriculture in improving crop productivity, improved livelihoods, and sustainable development.

1.7.3 Local Inhabitants

Findings from this research are going to play a pivotal role in the way farming is being done in Chimanimani district. This would allow informed decision in how conservation agriculture should be done to increase yield and reduce poverty among the citizens. It is with this research that the findings are going to find the effects which will be used to generate solutions that are centred on the actual problems as opposed to solutions that may have been used in other communities.

1.8 Assumptions

The research is based on the following assumptions:

- Conservation agriculture practices can contribute to improved soil health, increased crop yields, and enhanced socio-economic outcomes in rain-fed farming systems.
- Farmers in Chimanimani District are willing and able to adopt CA practices given adequate support and resources.
- The sample of selected respondents will be a true representation of the people of Chimanimani District.
- That gathered information shall be used for the purposes of academics.

1.10 Limitations

The limitations of this study were shaped by several factors that impacted the scope and generalizability of the findings. First, the study's findings may not be fully generalizable to other regions with different agroecological and socio-economic contexts, as it focused specifically on Chimanimani District. The unique environmental and cultural conditions in this district may have influenced the outcomes of conservation agriculture differently than in other areas. Additionally, the study faced logistical challenges during data collection due to the remote, rural setting of the selected communities, making access to respondents difficult. Budgetary constraints limited the researcher's ability to travel extensively across the district, which may have affected the comprehensiveness of the data. Furthermore, the study relied heavily on self-reported data from farmers, which could have introduced biases or inaccuracies. Despite these limitations, the

research provides valuable insights into the effects of conservation agriculture under rain-fed conditions and offers a foundation for future studies in similar contexts.

1.11 Delimitations of the study

The research has been conducted in Chimanimani District, the geographical features and boundaries have been presented by form of coordinates and maps. Thematic maps and google maps of selected communities in Chimanimani have been formulated to represent Mhandarume, Wengezi and Chakohwa. The study assessed conservation agriculture in promoting crop production efficiency, food security and resilience under rain-fed conditions in the selected 3 communities in Chimanimani District. The study was conducted over a period of Four (4) month beginning January 2024 till April 2024.

1.12 Definition of Terms

Key terms and concepts relevant to the study, such as conservation agriculture and rain-fed farming, will be defined and clarified to ensure clarity and understanding of the concepts underpinning this research.

Conservation Agriculture

Conservation agriculture is a sustainable farming approach that involves minimizing soil disturbance, maintaining permanent soil cover, and practicing crop rotation or diversification (Kassam et al., 2019). It aims to enhance soil health, reduce erosion, conserve water, and improve crop productivity while minimizing environmental impacts (Kassam, 2020). On the other note, Thierfelder et al. (2018) posited that conservation agriculture refers to a set of farming practices characterized by minimal soil disturbance, continuous soil cover, and diversified crop rotations. These practices aim to improve soil structure, fertility, and water retention, thereby promoting sustainable agricultural production and ecosystem resilience. This therefore means, conservation agriculture is an agricultural management system that involves minimal soil disturbance, continuous soil cover, and diverse crop rotations. By preserving soil health and ecosystem services, conservation agriculture promotes sustainable and resilient farming practices that benefit both farmers and the environment (Rodenburg et al., 2021).

Rain fed farming.

Rain-fed farming refers to agricultural systems that rely primarily on natural rainfall for crop irrigation, without the use of supplemental irrigation from sources such as rivers, lakes, or groundwater (Sathyan et al., 2018). It is practiced in regions where precipitation is sufficient to support crop growth without the need for artificial irrigation. Rain-fed farming, also known as dryland farming, involves cultivating crops solely using precipitation as the primary water source (Wahab, 2020). It is practiced in areas where rainfall patterns and soil moisture levels are sufficient to sustain crop growth during the growing season without additional irrigation inputs. This gives a working definition that rain-fed farming encompasses agricultural practices that rely on rainfall to meet the water needs of crops throughout their growth cycle. This method of farming is prevalent in regions where precipitation patterns provide adequate moisture for crop cultivation without the need for supplemental irrigation. Rain-fed farming systems vary in their resilience to climate variability and can be susceptible to droughts and other weather extremes, highlighting the importance of sustainable land management practices and crop diversification to enhance productivity and resilience.

1.13 Summary

In summary, this chapter provides an overview of the research topic, objectives, and rationale, setting the stage for the subsequent chapters of the dissertation. By investigating the effects of conservation agriculture under rain-fed conditions in Chimanimani District, the study aims to contribute to the advancement of sustainable agricultural practices and rural development in the region.

CHAPTER 2: LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1 Introduction

This chapter delves into an extensive review of the existing literature on the effects of conservation agriculture under rain-fed conditions, with a specific focus on the Chimanimani District of Zimbabwe. This chapter aims to provide a comprehensive understanding of the subject matter by exploring various studies, theories, and research findings related to conservation agriculture and its implications in rain-fed areas. This literature review will explore various dimensions of conservation agriculture, including its impact on soil health, crop yield, biodiversity, and climate change mitigation. It will also examine the challenges and opportunities associated with implementing conservation agriculture in rain-fed conditions, drawing on case studies and empirical evidence from Chimanimani District and similar contexts. By synthesizing key insights from a diverse range of sources, this chapter will contribute to a more nuanced understanding of conservation agriculture's role in promoting sustainable agricultural practices and resilience in rain-fed farming systems.

2.2 Theoretical Framework

Underpinning theories

The theories underpinning this study include the theory of sustainable agriculture and the theory of agroecology. These two theories are critical for this study and have been used to buttress research findings for this study.

2.2.1 Theory of sustainable agriculture

This theory posits that sustainable agriculture is a method that does not deplete soil, water, air, wildlife or human community resources (Rose et al., 2019). It emphasizes long-term sustainability of the agricultural system, promoting soil health, minimizing water usage, and lowering pollution levels on the farm. Applying this theory to conservation agriculture in the Chimanimani District would involve assessing how conservation agriculture practices contribute to the sustainability of the agricultural system. This could include studying the impact of these practices on soil health, water usage, and pollution levels in the district.

One weakness of this theory is that it may not take into account the socio-economic realities of farmers in the Chimanimani District. Sustainable agriculture practices can sometimes be more costly or labor-intensive, which may not be feasible for all farmers.

2.2.2 Agroecology Theory

Agroecology theory represents a paradigm shift in agriculture, emphasizing the interconnectedness of ecological processes within agricultural systems (Bell & Bellon, 2018). At its core, agroecology recognizes that agricultural practices should be harmonized with natural ecosystems to achieve sustainable food production while minimizing negative environmental impacts. This theory suggests that by mimicking natural ecosystems' diversity and complexity, agricultural systems can enhance soil fertility, increase resilience to environmental stressors, and promote long-term productivity.

Agroecology theory emerged from interdisciplinary research conducted by scientists, agronomists, ecologists, and farmers seeking alternatives to conventional, input-intensive agricultural practices (Bello Cartagena, 2019). The origins of agroecology can be traced back to various movements and initiatives worldwide, including the sustainable agriculture movement in the United States, the organic farming movement in Europe, and traditional farming practices in indigenous communities across the globe. Over time, agroecology has gained recognition as a viable approach to address the social, economic, and environmental challenges facing agriculture.

The importance of agroecology to the study of conservation agriculture under rain-fed conditions in Chimanimani District lies in its holistic approach to agricultural management. Conservation agriculture practices, such as minimal soil disturbance, crop rotation, and cover cropping, align closely with agroecological principles by promoting biodiversity, improving soil structure, and enhancing ecosystem services. By integrating agroecological concepts into agricultural practices, farmers in Chimanimani District can potentially mitigate soil erosion, improve water retention, and reduce reliance on external inputs, thus fostering more sustainable and resilient farming systems in the face of climate variability.

Agroecology has been successfully implemented in diverse agricultural contexts around the world. For example, in Latin America, agroecological approaches have been widely adopted by small-scale farmers to improve food security, conserve natural resources, and enhance rural livelihoods (Nichols & Altieri, 2018). In sub-Saharan Africa, initiatives such as farmer field schools and participatory research projects have promoted agroecology as a means to increase resilience to climate change, improve soil fertility, and empower local communities. Additionally, in Southeast Asia, agroecological principles have been integrated into sustainable rice production systems,

leading to higher yields, reduced input costs, and improved environmental sustainability. These successful examples demonstrate the potential of agroecology to transform agricultural systems and contribute to more equitable and resilient food systems globally.

However, despite its potential benefits, agroecology theory also presents certain weaknesses and challenges. One notable challenge is the complexity of agroecological systems, which can make them difficult to manage and optimize, especially for farmers with limited resources or technical expertise (Saliou, Muradian & Barnaud, 2019). Additionally, the transition to agroecological practices may require significant changes in farming practices and social norms, which could encounter resistance from farmers accustomed to conventional agricultural methods. Furthermore, the scalability of agroecological approaches to large-scale commercial agriculture remains a subject of debate, as some argue that the yields may not be as high as those achieved with intensive monoculture systems.

In summary, agroecology theory offers a compelling framework for understanding and improving agricultural sustainability in Chimanimani District. By embracing agroecological principles and practices, farmers can potentially enhance the resilience and productivity of rain-fed agricultural systems while minimizing environmental degradation. However, realizing the full potential of agroecology requires addressing challenges related to management complexity, social acceptance, and scalability, highlighting the need for further research, education, and policy support to facilitate the transition towards more sustainable and resilient agricultural systems.

2.3 Importance of Conservation Agriculture

Conservation agriculture is a sustainable farming approach that emphasizes the preservation and enhancement of soil health, biodiversity, and natural resources while promoting higher yields and economic profitability. Its significance lies in its ability to address multiple challenges facing modern agriculture, ranging from soil degradation and erosion to water scarcity and climate change.

Firstly, conservation agriculture promotes soil health by minimizing soil disturbance, maintaining permanent soil cover, and diversifying crop rotations. By reducing tillage, farmers preserve soil structure, organic matter content, and beneficial soil organisms, which are essential for nutrient cycling and water retention. This leads to improved soil fertility, resilience to erosion, and

enhanced carbon sequestration, thereby ensuring long-term productivity and sustainability of agricultural lands.

Secondly, conservation agriculture contributes to water conservation and efficiency in farming systems. By keeping the soil covered with crop residues or cover crops, evaporation is reduced, and moisture retention is increased, especially in regions prone to drought. This not only optimizes water use efficiency but also mitigates the risk of soil erosion and nutrient leaching, thus safeguarding water quality and availability for both agricultural and non-agricultural purposes.

Thirdly, conservation agriculture plays a crucial role in mitigating climate change and reducing greenhouse gas emissions. By enhancing soil organic matter content and minimizing tillage, carbon sequestration rates in agricultural soils can be significantly increased, acting as a carbon sink to offset emissions from agricultural activities. Additionally, the use of cover crops and diversified cropping systems can contribute to reducing the reliance on synthetic fertilizers and pesticides, further decreasing the carbon footprint of agriculture.

Furthermore, conservation agriculture fosters biodiversity conservation and promotes ecological balance within agroecosystems. By adopting practices such as crop rotation, intercropping, and agroforestry, farmers create habitats for beneficial insects, pollinators, and natural predators, which contribute to pest control and pollination services. This reduces the need for chemical inputs, enhances natural pest resistance, and promotes ecosystem resilience, ultimately leading to more sustainable and resilient farming systems.

In conclusion, conservation agriculture offers a holistic and sustainable approach to modern farming that addresses the interconnected challenges of soil degradation, water scarcity, climate change, and biodiversity loss. By prioritizing soil health, water conservation, climate mitigation, and biodiversity conservation, conservation agriculture not only ensures the long-term productivity and profitability of agricultural lands but also contributes to the broader goals of environmental stewardship and food security for present and future generations. Therefore, investing in the adoption and promotion of conservation agriculture practices is imperative for building resilient and sustainable agricultural systems worldwide.

2.4 Discussion of existing models and frameworks

In the realm of conservation agriculture, several models play a crucial role in understanding and promoting sustainable agricultural practices.

2.4.1 Regional Suitability Models

Regional suitability models assess the suitability of specific geographic regions for implementing conservation agriculture practices. These models consider local climate conditions, soil characteristics, topography, and land use patterns to identify areas where conservation practices are most appropriate and effective. They help policymakers and agricultural stakeholders prioritize interventions and allocate resources based on regional needs and constraints. However, regional suitability models may oversimplify the heterogeneity of agroecosystems within a region and fail to account for localized factors that influence agricultural sustainability. Addressing these limitations requires more robust data collection and validation processes to improve the accuracy and relevance of regional suitability assessments.

2.4.2 Empirical Models

Empirical models are based on observed data and relationships between various agricultural variables such as soil properties, water availability, and crop performance. These models are valuable for predicting outcomes based on historical data and field observations. They provide practical insights into the impacts of conservation agriculture practices on soil health, crop yields, and water usage. However, empirical models may have limitations in accurately capturing complex interactions within agricultural systems, especially in dynamic environments. The research gap lies in the need for further refinement and validation of empirical models to enhance their accuracy and reliability in diverse agroecological settings.

2.4.3 Meta-Models

Meta-models combine information from multiple existing models to improve predictive accuracy and robustness. These models integrate diverse sources of data, knowledge, and expertise to generate more reliable forecasts and recommendations. Meta-models can address uncertainties and limitations associated with individual models by leveraging complementary strengths and insights from different approaches. They offer a holistic framework for synthesizing existing knowledge and guiding decision-making in agricultural systems. However, meta-models may introduce additional complexity and challenges related to model integration, calibration, and validation.

Future research should focus on refining meta-modeling techniques and developing standardized protocols for model integration and evaluation to enhance their practical utility and reliability.

2.4.4 Decision Models

Decision models assist farmers, policymakers, and other stakeholders in making informed choices regarding conservation agriculture practices. These models consider economic, environmental, and social factors to evaluate the costs, benefits, and trade-offs associated with different management options. Decision models help optimize resource allocation, prioritize interventions, and design adaptive strategies for sustainable agricultural development. However, decision models may face challenges related to data availability, stakeholder engagement, and uncertainty quantification. Addressing these challenges requires interdisciplinary collaborations and participatory approaches to model development and implementation. Additionally, integrating decision models with real-time monitoring and feedback mechanisms can enhance their effectiveness in supporting evidence-based decision-making in dynamic agricultural systems.

2.4.5 Biophysical Models

Biophysical models integrate biological and physical processes to simulate agricultural systems and predict outcomes under different management scenarios. These models incorporate detailed representations of soil dynamics, crop growth, water movement, and nutrient cycling to assess the impacts of conservation agriculture practices on ecosystem functioning. Biophysical models are valuable tools for understanding complex interactions within agroecosystems and optimizing management strategies for sustainable outcomes. However, biophysical models may require extensive data inputs and computational resources, limiting their applicability in resource-constrained settings. Bridging this research gap involves developing simplified versions of biophysical models that retain key processes while reducing data requirements and computational complexity.

2.4.6 Meta-Models

Meta-models combine information from multiple existing models to improve predictive accuracy and robustness. These models integrate diverse sources of data, knowledge, and expertise to generate more reliable forecasts and recommendations. Meta-models can address uncertainties and limitations associated with individual models by leveraging complementary strengths and insights from different approaches. They offer a holistic framework for synthesizing existing knowledge and guiding decision-making in agricultural systems. However, meta-models may introduce

additional complexity and challenges related to model integration, calibration, and validation. Future research should focus on refining meta-modeling techniques and developing standardized protocols for model integration and evaluation to enhance their practical utility and reliability.

2.5 Empirical Literature

Empirical evidence on conservation agriculture provides valuable insights into its effectiveness in improving soil health, enhancing crop productivity, and promoting sustainability across diverse agricultural systems. Numerous studies have documented the positive impacts of conservation agriculture practices on soil properties, water retention, and crop yields, highlighting its potential to address key challenges facing modern agriculture.

Firstly, several researches consistently demonstrates that conservation agriculture leads to improvements in soil health by reducing soil erosion, increasing organic matter content, and enhancing soil structure (Gupta et al., 2020; Page, Dang & Dalal, 2020 & Seitz et al., 2019). Long-term field trials and observational studies have shown that minimal tillage, permanent soil cover, and crop diversification practices promote soil aggregation, microbial activity, and nutrient cycling, resulting in greater soil fertility and resilience to environmental stresses (Sithole, Magwaza & Thibaud, 2019). In countries like the United States and Canada, farmers have adopted no-till or reduced tillage practices coupled with crop rotation and residue management to minimize soil disturbance and maintain soil cover (Tully & McAskill, 2020). In Africa, countries such as Zambia and Zimbabwe have implemented conservation agriculture programs, promoting practices like minimum tillage, mulching, and cover cropping to improve soil fertility and resilience to erosion (Parwada, Chipomho & Madumbu, 2022). The success stories from these cases would be very important incites to the current study in Chimanimani area. Similarly, Mitchell et. al (2019) highlighted that in Asia, countries like India and China have embraced conservation agriculture techniques such as zero tillage and residue retention to conserve soil moisture and enhance soil organic matter content.

Secondly, empirical studies have highlighted the role of conservation agriculture in mitigating water-related challenges in agriculture, such as drought and water scarcity (Giordano, Barron & Unver, 2019). By maintaining soil cover and reducing tillage, conservation agriculture practices minimize water runoff, increase infiltration rates, and improve water retention in the root zone (Sahu, Mohanty & Das, 2020). This not only enhances water use efficiency but also reduces soil

erosion and nutrient losses, leading to more sustainable water management in agricultural landscapes. In Australia and Brazil, conservation agriculture practices such as direct seeding into stubble and controlled traffic farming have been adopted to reduce soil erosion and water runoff, especially in regions prone to drought (Farooq et al., 2020). Kenya and Ethiopia have implemented conservation agriculture initiatives, emphasizing practices like water harvesting, contour planting, and agroforestry to improve water retention and availability for crops (Karuku, 2018 & Nyawade & Karanja, 2019). Thailand and Indonesia on the other note have promoted conservation agriculture techniques like raised bed planting and alternate wetting and drying in rice paddies to optimize water use efficiency and mitigate water scarcity (Ishfaq et al., 2020).

Furthermore, empirical evidence suggests that conservation agriculture contributes to higher crop yields and profitability, particularly under challenging environmental conditions (Thierfelder et al., 2018). Meta-analyses of field experiments and on-farm trials have consistently shown that adopting conservation agriculture practices results in comparable or higher yields compared to conventional tillage systems, especially in rainfed and marginal environments (Magombeyi, Taigbenu & Barron, 2018). Moreover, cost-benefit analyses indicate that the long-term economic returns from conservation agriculture outweigh the initial investment costs, making it a financially viable option for farmers. Argentina and Paraguay, adoption of conservation agriculture practices such as no-till soybean production has led to significant yield gains and cost savings for farmers (Farooq et al., 2020). Malawi and Kenya have implemented conservation agriculture projects, demonstrating yield increases in maize and other staple crops through practices like minimum tillage and intercropping (Marambanyika, 2022 & Mupangwa et al., 2021). Similarly, countries like Bangladesh and Vietnam have embraced conservation agriculture approaches like the System of Rice Intensification (SRI), resulting in higher rice yields and reduced input costs for farmers (Uphoff, 2023).

Additionally, empirical studies highlight the environmental benefits of conservation agriculture in terms of reducing greenhouse gas emissions and preserving biodiversity (Chabert & Sarthou, 2020). By minimizing soil disturbance and promoting agroecosystem diversity, conservation agriculture practices enhance carbon sequestration in agricultural soils and provide habitat for beneficial organisms such as pollinators and natural enemies of pests (Tooker et al., 2020). This contributes to climate change mitigation and ecosystem resilience, aligning with broader

conservation goals and sustainable development objectives. France and Germany, adoption of conservation agriculture practices such as cover cropping and crop diversification has contributed to carbon sequestration in agricultural soils and preservation of habitat for wildlife (Farooq et al., 2020). Uganda and Tanzania have implemented conservation agriculture programs, promoting practices like agroforestry and integrated pest management to enhance biodiversity and ecosystem services (Aguti, 2023). Nepal and Sri Lanka have adopted conservation agriculture techniques like mixed cropping and organic farming to minimize environmental impacts and promote ecological balance (Thakur et al., 2022).

However, empirical evidence also points to challenges and constraints associated with the adoption and scaling up of conservation agriculture practices. Studies have identified barriers such as limited access to knowledge and information, lack of technical support and infrastructure, and socio-economic factors affecting farmers' decision-making processes. Addressing these challenges requires tailored extension programs, policy incentives, and institutional support to facilitate the adoption and mainstreaming of conservation agriculture at the farm and landscape levels. Despite its potential benefits, conservation agriculture faces challenges and constraints in adoption and scaling worldwide. In Africa, issues such as land tenure insecurity and access to inputs pose barriers to implementation (Dlamini & Ogunnubi, 2018). Addressing these challenges requires context-specific approaches tailored to local socio-economic conditions and institutional support mechanisms that facilitate knowledge dissemination and capacity building at the grassroots level.

Moreover, empirical research underscores the importance of context-specific approaches to conservation agriculture implementation, considering local agroecological conditions, socio-economic dynamics, and cultural preferences. One-size-fits-all solutions may not be suitable for diverse farming systems, highlighting the need for participatory approaches and adaptive management strategies that engage farmers as co-creators of knowledge and innovation.

2.6 Chapter Summary

Chapter 2 provided a comprehensive literature review on conservation agriculture, synthesizing empirical evidence from various regions worldwide, with a focus on Africa and Asia. The chapter explored the principles and practices of conservation agriculture, highlighting its significance in enhancing soil health, water management, crop productivity, and environmental sustainability. Drawing on a range of studies, the review examines how conservation agriculture has been

implemented in different countries, discussing both successful case studies and challenges faced in adoption and scaling. Additionally, the chapter identifies gaps in current research and knowledge, underscoring the need for context-specific approaches and interdisciplinary collaborations to advance understanding and promote the widespread adoption of conservation agriculture as a sustainable farming paradigm.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

This chapter describes the research methodology employed to examine the impacts of conservation agriculture in Chimanimani District under rain-fed conditions. The chapter elucidates the research design, which encompasses a natural experiment and a case study approach, instrumental in analyzing the effects of conservation farming. It provides insights into the target population of the study area, alongside delineating the sample population and the sampling techniques employed. Furthermore, it elucidates the meticulous data collection process, engaging key stakeholders actively. The chapter also elucidates the measures undertaken to bolster the validity and reliability of the research. It explores the utilization of both quantitative and qualitative data collection methods, delving into their significance and the nature of information they yield.

3.2 Research Paradigm

Saunders, Lewis and Thornhill. (2019), posited that research paradigms encompass the fundamental philosophical frameworks guiding the approach, methodology, and interpretation of research studies. They shape researchers' perceptions of reality and influence how they conceptualize and conduct their investigations. Basically, there are three major research paradigms which encompass; positivism, interpretivism, and realism (Bell, Bryman & Harley, 2022).

Positivism is a research paradigm rooted in the belief that knowledge can be obtained through empirical observation and experimentation (Bell, Bryman & Harley, 2022). Hamal and Sapkota, (2020) emphasized that it emphasizes objectivity, quantifiability, and the search for universal laws governing phenomena. Positivist researchers aim to uncover causal relationships and prefer quantitative methods, such as surveys and experiments, to collect and analyze data (Bell, Bryman & Harley, 2022; Hamal & Sapkota, 2020). They prioritize replicability and generalizability, seeking to produce findings that are reliable and applicable across contexts.

Interpretivism on the other hand dwells on the understanding of the subjective meanings and interpretations of individuals within their social arena (Saunders, Lewis & Thornhill, 2019). It works best with qualitative methods such as interviews, observations, and textual analysis to explore the complexities of human experiences and social phenomena (Bell, Bryman & Harley, 2022).

Realism posits that reality exists independent of human perception but can only be understood through our interpretations and perceptions (Bell, Bryman & Harley, 2022). It seeks to uncover underlying structures and mechanisms that shape observable phenomena, often employing mixed methods approaches to triangulate findings.

Post-positivism, also known as critical realism, combines elements of both positivism and constructivism while recognizing the limitations of each approach (Davies & Fisher, 2018). It acknowledges the existence of an objective reality but acknowledges that researchers can only approximate it through their subjective interpretations (Bell, Bryman & Harley, 2022). Post-positivist researchers strive for empirical rigor while also recognizing the influence of social and contextual factors on knowledge production (Hamal & Sapkota, 2020). They employ a mixed-methods approach (Bell, Bryman & Harley, 2022), integrating quantitative and qualitative methods to triangulate findings and provide a more comprehensive understanding of phenomena.

Each research paradigm offers a unique lens through which to view and engage with the research process, shaping the questions asked, the methods employed, and the interpretations made. By understanding and critically engaging with these paradigms, researchers can navigate the complexities of knowledge production and contribute meaningfully to their respective fields of study.

The current research adopts a post-positivism research philosophy to explore the effects of conservation farming under rain fed conditions in Chimanimani District, Zimbabwe. Post-positivism is chosen for its emphasis on understanding phenomena from multiple dimensions (Pandey & Pandey, 2021), and perspectives, aligning with the complexity of agricultural practices. This paradigm acknowledges the importance of widely held opinions, leading to the utilization of both quantitative and qualitative approaches (Park et al., 2020). Quantitative methods, including Likert scale questions, provide insights into farmers' perceptions of agricultural productivity and key capitals underpinning sustainable livelihoods. Qualitative methods, such as interviews, uncover recurring themes and subjective experiences, complementing quantitative findings.

Post-positivism advocates for triangulating qualitative and quantitative data to gain a comprehensive understanding of research phenomena (Pandey & Pandey, 2021). In this study, quantitative data collection involves close-ended questions and statistical analyses, while qualitative methods capture farmers' experiences through interviews. This holistic approach

ensures a nuanced understanding of the challenges and opportunities associated with conservation farming, facilitating the development of effective solutions.

Furthermore, post-positivism values all study findings, whether quantitative or qualitative, recognizing their contribution to knowledge generation (Bibi et al., 2022). The researcher empathizes with smallholder farmers, gathering data on personal experiences, demographics, and environmental contexts. This comprehensive approach enables the development of a conservation farming model that addresses farmers' needs and challenges, drawing on diverse sources of information to inform decision-making.

Lastly, post-positivism emphasizes assessing study findings within the natural environment of respondents to ensure contextual relevance. By employing a case study research design and engaging directly with smallholder farmers in Chimanimani District, the researcher gains firsthand insights into the challenges and opportunities within farmers' natural environments. This immersive approach fosters collaboration and co-creation of solutions tailored to the specific contexts and realities of smallholder farmers, enhancing the effectiveness and sustainability of conservation farming initiatives.

3.3 Research Approach

A research approach refers to the overarching strategy or plan employed by researchers to address a particular research question or objective (Saunders, Lewis & Thornhill, 2019). It encompasses the methods, techniques, and procedures used to collect, analyze, and interpret data within a study. Research approaches guide the overall direction of the investigation and influence the choice of research design, data collection methods, and analytical techniques. They serve as the roadmap for conducting research and ultimately shape the outcomes and conclusions of the study.

Quantitative research approaches involve the systematic collection and analysis of numerical data to answer research questions or test hypotheses (Apuke, 2017). This approach emphasizes objectivity, precision, and statistical analysis to draw conclusions about the relationships between variables. Quantitative research often utilizes structured instruments such as surveys, experiments, or observations to gather data, which are then analyzed using statistical methods to identify patterns, trends, or associations (Pandey & Pandey, 2021). This approach is particularly useful for studying large populations, measuring prevalence or frequencies, and establishing causal relationships between variables.

Qualitative research approaches focus on understanding the complexities and nuances of human experiences, behaviors, and perceptions through in-depth exploration and interpretation of textual or narrative data (Bell, Bryman & Harley, 2022). Qualitative research seeks to uncover rich, contextually embedded insights and meanings that may not be easily quantified or measured. It employs flexible, open-ended data collection methods such as interviews, focus groups, or observations to gather detailed descriptions and accounts from participants. Data analysis in qualitative research involves coding, categorizing, and interpreting the data to identify themes, patterns, or underlying meanings (Bell, Bryman & Harley, 2022). This approach is valuable for exploring subjective experiences, cultural phenomena, and social processes in depth.

Mixed-methods research approaches integrate both quantitative and qualitative methods within a single study to provide a more comprehensive understanding of the research problem (Pandey & Pandey, 2021). By combining the strengths of both approaches, mixed-methods research enables researchers to triangulate findings, validate results, and gain deeper insights into complex phenomena. Mixed-methods studies typically involve collecting and analyzing both quantitative and qualitative data concurrently or sequentially, allowing researchers to explore different facets of the research question and complement each other's strengths and weaknesses.

The researcher adopted a mixed method approach to collect data from farmers in Chimanimani District based on the research paradigm above which collineates with a mixed method approach. This approach offers flexibility and versatility, allowing researchers to tailor their methods to the specific research context and objectives. Qualitative research, favored for its ability to offer holistic insights, was instrumental in understanding the perspectives of farmers in Chimanimani District practicing conservation farming. This aligns with Atkinson and Delamont's (2010) assertion that qualitative methods are adept at uncovering underlying mechanisms and motives driving behavior, facilitating a nuanced exploration of individuals' experiences. Additionally, a quantitative approach was utilized to objectively describe respondents' opinions, as advocated by Apuke (2017), aiming to maximize objectivity, replicability, and generalizability of findings while minimizing researcher biases. By combining both qualitative and quantitative methods, the study achieved a comprehensive understanding of the complexities surrounding conservation farming adoption, ensuring rigor and depth in its analysis.

3.4 Research Design

Research design refers to the overall plan or strategy that guides the process of collecting, analyzing, and interpreting data to address research questions or objectives (Siedlecki, 2020). It outlines the framework within which researchers conduct their studies, detailing the methods, procedures, and techniques used to gather empirical evidence and draw conclusions. Research designs provide structure and direction to the research process, helping researchers to systematically investigate phenomena and generate meaningful insights (Saunders, Lewis & Thornhill, 2019).

Experimental research designs involve manipulating independent variables to observe their impact on dependent variables, with random assignment of participants to control and experimental groups ensuring strong causal inference (Pandey & Pandey, 2021). Correlational designs examine associations between variables without manipulation, providing insight into natural relationships but lacking causal inference (Hamal & Sapkota, 2020). Descriptive research characterizes phenomena without manipulation, offering detailed summaries but limited explanatory depth (Apuke, 2017). Qualitative research delves into the meanings and experiences of individuals, using open-ended methods to capture rich insights and inform theories grounded in lived experiences (Pandey & Pandey, 2021). Each design offers unique strengths and limitations in addressing research questions and understanding phenomena.

The researcher employed a case study approach to delve deeply into the outcomes of adopting conservation farming under rain fed conditions, utilizing both qualitative and quantitative research methods. This strategy, as conceptualized by Openheimer (1990), provided a robust framework for drawing valid conclusions. Case studies, as defined by Bell, Bryman and Harley (2022), offer detailed narratives capturing project successes and providing crucial outcome data for program evaluation, drawing from various sources such as interviews and focus group discussions. This approach allows researchers to understand behavioral conditions from participants' perspectives, using interviews, questionnaires, and focus group discussions to gather data.

The quality of the case study was evaluated according to four logical tests proposed by Yin (2016): construct validity, internal validity, external validity, and reliability. To meet the test for construct validity, the study used multiple sources of evidence and encouraged convergent lines of inquiry during data collection. Internal validity was ensured by identifying potential confounders that

could affect agricultural productivity, while external validity was addressed by seeking to generalize results to a larger population through analytical generalization.

The final test in the case study design focused on ensuring the reliability of study findings. Documentation of research design, data collection methods, and analysis procedures was critical to enhancing reliability (Yin, 2016). By thoroughly documenting every aspect of the study, the researchers aimed to increase the likelihood that the findings would be reproducible if the study were repeated. This attention to detail and transparency in methodology contributes to the reliability and credibility of the study's conclusions.

3.5 Population

The population refers to the entire group of individuals or items that share a common characteristic and are of interest to the researcher (Bell, Bryman & Harley, 2022). It represents the broader target group from which a sample is drawn to make inferences about the population as a whole. Chimanimani District, situated in the Manicaland province of Zimbabwe, is home to an estimated population of 153,619 individuals and 39,155 households, distributed across approximately 3 345km², as reported by National Census report in 2022. This population resides in an agricultural region characterized by high rainfall, limited crop production due to steep slopes categorizing Chimanimani District as susceptible to food insecurity. Livelihoods revolve around agriculture, mining, and small-scale businesses for the community in Chimanimani District. The population of the district for the purpose of this research has focused on 2 wards which are Cashel and Mhandarume with a total population of 2,155,468 households according to the national census (Zimstat, 2022).

Geographical Position of Chimanimani District

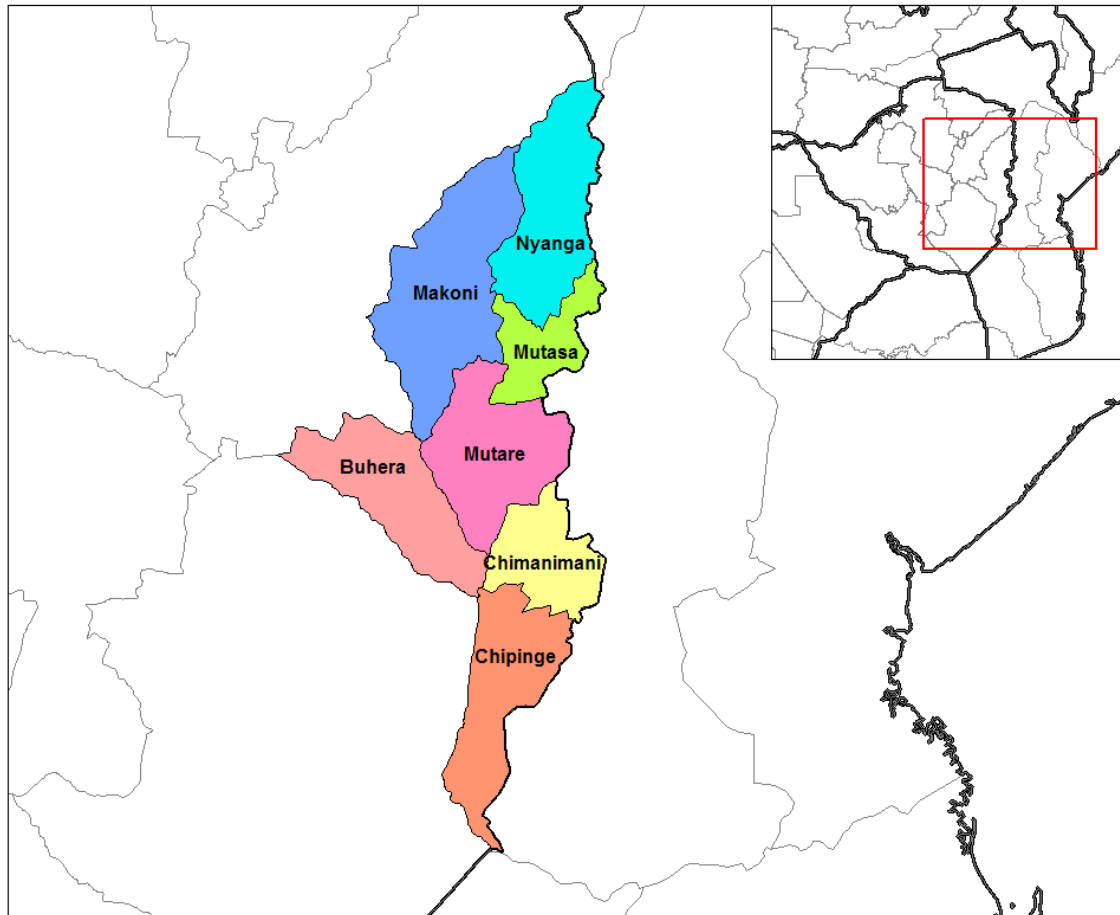


Figure 1 Geographical location of Chimanimani District

3.5.1 Sampling Frame

The sampling frame for the research consisted of all communal farmers in Chimanimani District defined by Turner (2003) as the set of source materials from which the study sample is selected in ward one covering Cashel and ward 2 covering Mhandarume. These wards have been chosen as areas that represent the district and have been convenient to the researcher. This list frame, obtained from the agricultural extension department, provided details on the type of farming practiced in different wards as well as information on various farmers. It facilitated the identification of wards with smallholder and commercial farmers, aiding in the intentional selection of wards for the study. The ability to categorize farmers numerically based on their farming approach was instrumental in systematically assigning smallholder farmers to either the treatment or control group in a logical manner.

3.5.2 Sample Size

The district houses about 2,155 households from the selected wards which are Cashel with 1,271 households and Mhandarume with 884 households. To determine the sample size for this study, the Raosoft calculator was adopted.

Raosoft Sample Size

| | | |
|--|-----------------------------------|---|
| What margin of error can you accept? | <input type="text" value="5"/> | % |
| 5% is a common choice | | |
| What confidence level do you need? | <input type="text" value="90"/> | % |
| Typical choices are 90%, 95%, or 99% | | |
| What is the population size? | <input type="text" value="2155"/> | |
| What is the response distribution? | <input type="text" value="50"/> | % |
| Leave this as 50% | | |
| Your recommended sample size is | 241 | |

Source: Raosoft: 2024

3.6 Sampling techniques

Sampling techniques are methods used to select a subset of individuals or items from a larger population for the purpose of conducting research (Stratton, 2021). Various sampling techniques exist, each with its own advantages and limitations. Random sampling involves selecting individuals from the population at random, ensuring every member has an equal chance of being chosen, thus providing a representative sample (Creswell & Creswell, 2018). Stratified sampling involves dividing the population into subgroups or strata based on certain characteristics, then randomly selecting samples from each stratum to ensure representation of all groups (Saunders, Lewis & Thornhill, 2019). Systematic sampling involves selecting every n th individual from a population list, providing a structured yet random approach (Cresswell & Cresswell, 2018). Convenience sampling involves selecting individuals who are readily available and accessible, while purposive sampling involves deliberately selecting participants who possess specific characteristics relevant to the research study (Bell, Bryman & Harley, 2022). Each sampling technique has implications for the generalizability and validity of study findings, and the choice

of technique depends on factors such as research objectives, population characteristics, and practical considerations.

3.6.1 Purposive sampling

In this study, purposive sampling was employed to deliberately select the study area, focusing specifically on wards where conservation farming is predominantly practiced within Chimanimani District and to the convenient of the researcher. Purposive sampling involves the researcher's expertise and judgment in choosing participants deemed most relevant to the study (Cresswell & Cresswell, 2018). Wards 1 and 2 in Chimanimani District were purposively sampled, intentionally excluding other wards largely occupied by commercial farmers. This targeted sampling approach aligns with the study's objectives and enhances the depth of understanding regarding conservation farming in the specified context.

3.6.2 Simple random sampling

In this study, simple random sampling was utilized to select participants from the farmer register provided by agricultural extension officers. This method ensures that each element in the study area has an equal chance of being included in the sample (Pandey & Pandey, 2021). This approach ensured equal representation from both groups of communal farmers practicing conservation farming and conventional farming as well as commercial farmers, allowing each farmer an opportunity to participate in the study.

3.7 Data collection methods

The researcher initiated the study by obtaining authorization from the provincial administrator for Manicaland Province, facilitated by the Ministry of Local Government and Public Works. This approval, received in the form of a letter, was then presented to the district administrator for Chimanimani, who played a pivotal role in introducing the researcher to relevant stakeholders, including the agricultural extension department, ward councilors, and the traditional chiefs overseeing wards. Securing authorization was crucial for garnering support from local leadership, easing access to study respondents.

Before proceeding with data collection, the researcher conducted a pilot test of the questionnaire. This trial run allowed for monitoring of completion times and ensured respondents' comprehension of the questions. Feedback from smallholder farmers, obtained through focus group discussions,

guided revisions to the questionnaire, including the addition of response options based on respondents' suggestions.

Utilizing registers maintained by the agricultural extension department, the researcher identified smallholder farmers practicing conservation farming and those using conventional methods. This categorization facilitated the assignment of farmers to treatment and control groups. Subsequently, simple random sampling was employed to select participants from both groups for inclusion in the study.

Administering the questionnaire involved visiting smallholder farmers at their farms. The researcher explained the study's purpose and ethical considerations to participants before collecting completed questionnaires on the same day. This approach ensured a high response rate and maintained ethical standards.

Following questionnaire administration, research questions were issued to respondents and were answered as guided in the questionnaire. All questions asked were in line with the research guide and research objectives that were set in the first chapter. The researcher also conducted interviews with participants selected through purposive sampling which aimed to tackle issues that could not be put in writing on the questionnaire as part of complimenting results of the questionnaire. These interviews complimented research findings that were done. Efforts were made to ensure gender diversity in these interviews. The motivation for farmers to attend stemmed from their interest in improving food security within their communities, aligning with the study's objectives.

3.8 Data Analysis

The researcher conducted both quantitative and qualitative data analysis. Quantitative analysis was done through the use of tables, graphical representation and cross tabulation in excel.

3.8.1 Qualitative Data Analysis

The researcher employed thematic analysis to scrutinize responses from interviews, ensuring comprehensive coverage of recurring themes. This involved transcribing and organizing data into meaningful themes and categories, following Maguire and Delahunt's (2017) six-step qualitative data analysis process. Initial familiarization with the data by reading and re-reading transcribed material preceded the generation of codes aimed at systematically organizing data relevant to research questions. Colors were assigned to codes corresponding to specific research areas for clarity. Subsequently, codes were synthesized into overarching themes aligned with the study's

objectives, with some themes encompassing multiple codes. The researcher utilized NVivo software to expedite the review process, ensuring themes were coherent and aligned with research objectives. Findings were then articulated in a clear write-up, capturing farmers' experiences and perceptions of conservation farming effects.

3.8.2 Quantitative Data Analysis

In addition to qualitative analysis, quantitative data analysis techniques, were employed. This facilitated the swift quantification of data for graphical representation using graphs, pie charts, and cross-tabulation tables. A template was created to organize quantitative questionnaire responses, allowing for the calculation of measures of central tendency such as mode, range, and mean average responses. Cross-tabulations were conducted to explore relationships between variables such as farming type and agricultural productivity, gender, and farming experiences. This comprehensive analysis approach enabled the researcher to draw meaningful conclusions from both qualitative and quantitative data, enriching the study's findings.

3.9 Data Presentation

3.9.1 Qualitative Data Presentation

Qualitative data will be presented using direct quotations, thematic tables, and narrative summaries to convey the rich, detailed insights obtained from interviews. Selected direct quotations from farmers will be included to vividly illustrate their experiences and perceptions of conservation farming effects. These quotations will provide a personal and contextual element to the data, helping to humanize the findings and ground them in real-world experiences. Thematic tables will summarize the overarching themes, sub-themes, and the frequency of related codes, providing a clear and organized overview of the qualitative data. Additionally, detailed narrative summaries of each theme will be included, supported by direct quotations and contextual explanations, to offer a comprehensive understanding of the qualitative findings.

3.9.2 Quantitative Data Presentation

Quantitative data will be presented through tables, graphs, and cross-tabulation tables to effectively visualize and summarize the statistical analysis. Tables will display summary statistics such as measures of central tendency (mean, mode, range) for key variables, offering a clear and concise overview of the data distribution. Graphs and charts, including bar graphs, pie charts, and line graphs, will be used to visually represent the distribution and relationships between variables,

making it easier to identify patterns and trends. Cross-tabulation tables will explore relationships between different variables, such as the impact of farming type on agricultural productivity or gender differences in farming experiences, providing a detailed examination of these associations. These visual aids will ensure that the quantitative data is presented in an accessible and informative manner, allowing for straightforward interpretation and analysis.

3.10 Validity and Reliability

To safeguard internal validity, which pertains to attributing study results accurately to the independent variable (in this case, conservation farming), and to enhance the generalizability of findings (external validity), the study adopted a natural experiment approach. Natural experiments, as described by Mckenna and Morrison (2010), allow for the comparison of populations that have received an intervention with those that have not, simulating a randomized experiment in situations where true randomization is not feasible. Additionally, the researcher rigorously tested for construct validity, internal validity, external validity, and reliability. These tests are essential for ensuring the validity and trustworthiness of research findings, particularly in studies employing a case study approach, as outlined in the research design section. This multifaceted approach to validity assessment strengthens the credibility and applicability of the study's results.

To ensure consistency in research findings, the researcher implemented measures to minimize participant error and bias. Data collection was scheduled in the afternoon, after participants had completed their daily tasks, to maximize their concentration. Guidance from traditional leadership helped determine the most convenient time for data collection. Additionally, the researcher emphasized the importance of truthful responses to participants and explained how their honesty would contribute to the study's validity.

According to Mohajan (2017), reliability refers to the consistency and stability of research findings. Test-retest reliability involves administering the same measure twice to assess stability over time. Typically, this involves correlating scores from two administrations of the same test to determine consistency. High reliability coefficients, measuring above 0.7, are deemed acceptable, while those above 0.8 are considered very good. To ensure reliability of the questionnaire in this study, a test-retest was conducted one month after initial data collection with 10% of respondents from both control and treatment groups. These respondents were selected through convenient sampling during transect walks. The researcher focused on questions related to financial, social,

and human capital, calculating intra-class correlation coefficients to measure the relationship between responses in the first and second tests. Hobbs (2017) notes that without good reliability, researchers may struggle to trust the accuracy of their data. Results indicated high reliability coefficients above 0.8 for questions assessing financial resources (0.924), social networks (0.899), and understanding of conservation farming principles (0.881). These findings suggest that the data collected was stable and reliable over time, enhancing confidence in the study's outcomes.

3.11 Ethical Considerations

Ethics in research, as defined by Resnik (2017), are standards of conduct that differentiate between acceptable and unacceptable behavior. To address ethical considerations, the researcher ensured that participants were not exposed to physical or emotional harm throughout the study. Additionally, the confidentiality of the data collected from participants was strictly maintained, respecting their privacy and protecting sensitive information. These measures were essential in upholding ethical standards and ensuring the well-being and rights of the research participants.

Informed consent

Informed consent, as described by Lahey (2020), is essential in research data collection, involving a process where participants are educated about the research's purpose and its potential benefits and risks. This process serves as an ethical obligation to safeguard participants' well-being. The researcher ensured that participants were informed about the study's advantages, crucial for obtaining consent from smallholder farmers to participate and contribute to solutions for enhancing agricultural productivity. Additionally, participants were assured of anonymity, as the data collection tools didn't require identifiable information. Despite potential reluctance to disclose information regarding government-assisted programs due to perceived political implications, participants were assured that their responses were solely for research purposes and wouldn't be linked directly to them.

Confidentiality

Maintaining confidentiality during data collection is equally crucial in research to uphold participants' trust and protect their privacy, as emphasized by House et al. (1996). The researcher ensured that participants understood how their identities would be handled concerning the information they provided. Participants were assured that the data collected was solely for research

purposes and would be securely recorded and stored, with their names kept anonymous. During interviews, some participants sought validation by inquiring about their peers' opinions or issues raised. The researcher clarified that information shared by peers was confidential and couldn't be divulged to others. This clarification on confidentiality encouraged some participants to provide more information, feeling reassured that their confidentiality was safeguarded.

Debriefing of participants

Debriefing participants after the study was essential for clarifying their involvement and increasing their understanding of conservation agriculture. The researcher provided a debriefing form detailing the research title and key results from farmers practicing conservation farming and those using conventional methods. This process facilitated engagement with participants in developing a prototype model of conservation farming based on the study findings.

3.12 Chapter Summary

The chapter has elucidated post-positivism as the research paradigm underpinning the study's framework. It delves into the rationale behind employing the natural experiment and case study designs to shape the research methodology. Additionally, the chapter outlines the various methods employed for data collection in the field. It elaborates on the utilization of both quantitative and qualitative analysis tools, offering insights into the step-by-step process of data analysis. Moreover, the chapter underscores the ethical considerations adhered to, ensuring that the research aligns with ethical standards.

CHAPTER 4: DATA COLLECTION, ANALYSIS AND PRESENTATION

4.1 Introduction

Data Collection, Analysis, and Presentation delves into the intricate process of gathering empirical evidence, analyzing it meticulously, and presenting findings in a coherent manner. This chapter serves as a crucial bridge between the theoretical framework established in earlier chapters and the tangible outcomes of the research endeavor. Through a comprehensive exploration of the data collection methods employed, including both quantitative and qualitative approaches, readers gain insight into the systematic approach taken to gather insights from the study population. Subsequently, the chapter delves into the analytical techniques utilized to make sense of the collected data, providing a nuanced understanding of the research phenomena. Finally, the presentation of findings encapsulates the culmination of the research journey, offering readers a clear and concise synthesis of key outcomes and implications. Through this chapter, readers are invited to traverse the intricate landscape of data collection, analysis, and presentation, ultimately illuminating the path towards informed decision-making and meaningful contributions to the field.

4.2 Response rate

Table 1: Response Rate

| Questionnaire distributed | Questionnaires Responded | Percentage |
|---------------------------|--------------------------|------------|
| 241 | 190 | 78.8% |

Source: Primary

With an impressive 78.8% response rate, the results of the data analysis reveal compelling insights into the impacts of conservation agriculture in Chimanimani District under rain-fed conditions. Through a combination of quantitative and qualitative approaches, the study uncovered multifaceted perspectives on agricultural productivity, livelihood sustainability, and the adoption of conservation farming practices among smallholder farmers. Quantitative analysis, including statistical tests and cross-tabulations, provided robust evidence of the positive effects of conservation farming on maize crop production, particularly evident in comparison to conventional farming methods (Nyandakyi-Frimpong, 2020). Moreover, qualitative analysis enriched these findings by offering nuanced narratives and contextual understanding, shedding light on the socio-economic factors influencing farmers' decisions and experiences. Overall, the findings underscore the potential of conservation agriculture as a viable approach to enhancing food security and livelihood resilience in Chimanimani District, while also highlighting the

importance of tailored interventions and support mechanisms to facilitate widespread adoption and long-term sustainability.

4.3 Demographic Analysis

A total of 190 households were surveyed in Chimanimani District in two selected wards to assess the effects of conservation agriculture under rain-fed conditions. The sample consisted of 106 male (56%) and 84 female (44%) respondents. The majority of respondents (43%) were between 31-40 years old, followed by 41-50 years (27%), 21-30 years (18%), and over 50 years (12%). In terms of education, 41% had secondary education, 32% had primary education, 15% had tertiary education, and 12% had no school certificate. The average household size was 5.2 members. This is slightly higher than the national average of 4.2 persons per household in Zimbabwe (Ncube, 2021). Large household sizes are common in rural areas due to extended family structures and high fertility rates (Ncube, 2021). However, having more dependents can put a strain on household resources and food security, especially for smallholder farmers.

4.4 Results

4.4.1 Changes in Soil Health indicators

Table 2: Changes in Soil Health

| Observes Changes in Soil Health Indicators | Frequency |
|---|------------------|
| Yes | 133 |
| No | 57 |

With a total sample size of 190 households, 133 households (70%) reported observing changes in soil health indicators since adopting conservation agriculture practices, while 57 households (30%) did not observe any changes. The findings suggest a significant positive perception among households regarding the impact of conservation agriculture practices on soil health indicators. Approximately 70% of the surveyed farmers reported observing changes, indicating a widespread belief in the effectiveness of these practices in enhancing soil health. This aligns with existing literature, which often highlights conservation agriculture as a sustainable approach to soil management, promoting soil fertility, structure, and moisture retention (Kassam et al., 2019; Pittelkow et al., 2015). Farmers' observations of improved soil health indicators corroborate with

studies emphasizing the benefits of reduced tillage, crop residue retention, and diversified cropping systems in conserving soil quality and promoting long-term agricultural sustainability (Nunes et al., 2020; Dagunga, Abubakari & Awuni., 2021). The relatively high proportion of farmers reporting positive changes underscores the potential of conservation agriculture to address soil degradation challenges in rain-fed farming systems, offering promising pathways towards achieving sustainable agricultural intensification and food security in the region. However, further research may be warranted to assess the long-term sustainability and resilience of these practices under diverse agroecological and socio-economic contexts.

4.4.2 The effects of CA on yields

Table 3: Effects of CA on Yields

| Changes in Yield Per Hectare | Frequency |
|------------------------------|-----------|
| Improved | 95 |
| No Change | 67 |
| Declined | 28 |

Source: Primary Data

The findings regarding average yield per hectare under conservation agriculture (CA) practices reveal a mixed picture. While a considerable proportion of farmers reported increased yields (49.79%), a notable percentage (35.26%) indicated no significant change, and a smaller group (14.94%) reported decreased yields. This variability in reported outcomes echoes the nuanced nature of agricultural practices and their impact on crop productivity. Literature on the subject provides insights into potential factors contributing to this variability. Pittelkow et al. (2015) and Shah and Wu (2019) suggest that the success of CA in improving crop yields depends on various factors, including soil type, climatic conditions, crop rotation strategies, and farmers' management practices. Positive yield responses to CA practices are often observed in scenarios where soil moisture retention and fertility are enhanced, leading to improved crop establishment, growth, and resilience to drought stress (Kassam et al., 2019; Derpsch et al., 2010). However, challenges such as initial yield penalties due to transitioning from conventional to CA practices, weed management issues, and limited access to inputs and technical support can hinder the realization of yield benefits

(Lee & Gambiza, 2022; Kassam et al., 2019). Therefore, while the findings suggest a significant proportion of farmers experiencing increased yields under CA practices, the presence of farmers reporting no change or decreased yields underscores the need for context-specific assessments and targeted interventions to maximize the potential of CA in enhancing agricultural productivity and food security in rain-fed farming systems.

4.4.3 Effects of CA on yield per Hectare for selected crops

Table 4: Effects of CA on Yields per Hectare

| Crop Type | Average Yield per Hectare (kg/ha) |
|-------------------|--|
| Maize | 1500 |
| Millet | 1300 |
| Sorghum | 1200 |
| Beans | 900 |
| Groundnuts | 800 |

Source: Primary Data

These results indicate the average yields per hectare for various crops under conservation agriculture practices. The data shows that maize has the highest average yield per hectare, followed by millet and sorghum. These findings are consistent with existing literature, which suggests that conservation agriculture practices, such as minimum tillage and residue retention, contribute to improved soil health and moisture retention, resulting in higher crop yields (Pittelkow et al., 2015). The higher yields observed in maize and small grains (millet and sorghum) could be attributed to their adaptability to conservation agriculture practices, highlighting the potential of these practices to enhance agricultural productivity and food security in rain-fed farming systems.

4.4.4 Measures to improve CA

Table 5: Measures to Improve CA

| Factors | Frequency |
|-------------------------------|------------------|
| Access to Resources | 54 |
| Economic Incentives | 29 |
| Environmental Concerns | 95 |
| Social Pressure | 12 |

Source: Primary Data

The data reveals that the primary factors influencing the adoption of conservation agriculture practices among farmers in Chimanimani District are environmental concerns, followed by access to resources and economic incentives. These findings align with existing literature, which highlights the importance of environmental sustainability and resource conservation in driving the adoption of conservation agriculture practices (Lee & Gambiza, 2022). Farmers may be motivated by the desire to mitigate environmental degradation, such as soil erosion and loss of biodiversity, while also seeking economic benefits, such as improved soil fertility and water conservation, which can lead to higher crop yields and reduced production costs. Additionally, the influence of social pressure on adoption decisions underscores the role of community norms and peer networks in shaping agricultural practices, as farmers may be encouraged to adopt conservation agriculture practices to align with prevailing social expectations.

4.4.5 Government Support on CA

Government Support on CA

Table 6: Government Support on CA

| Government Support | Frequency |
|---------------------------|------------------|
| Yes | 67 |
| No | 123 |

Source: Primary Data

The data suggests that a significant proportion of farmers in Chimanimani District perceive that current government policies do not adequately support the adoption of conservation agriculture practices. This finding is consistent with literature highlighting the challenges and limitations of government policies in promoting sustainable agricultural practices, particularly in less economically developed countries (Lee & Gambiza, 2022; Nyasimi et al., 2011). Limited access to resources, inadequate extension services, and conflicting policy priorities are often cited as barriers to the widespread adoption of conservation agriculture practices (Lee & Gambiza, 2022). Furthermore, the perceived lack of government support may hinder the scalability and sustainability of conservation agriculture initiatives, emphasizing the need for policymakers to address these challenges and create an enabling environment for farmers to adopt more sustainable farming practices.

4.4.6 Policy Recommendations

Table 7: Policy Recommendations

| Policy Changes/Interventions | Frequency |
|---|------------------|
| Improved access to agricultural extension services and training | 43 |
| Financial incentives or subsidies for adopting CA practices | 54 |
| Strengthening land tenure security and property rights | 38 |
| Infrastructure development (e.g., irrigation, roads, market) | 21 |
| Access to affordable inputs (seeds, fertilizers, pesticides, herbicides) | 16 |
| Government support in marketing and value addition | 18 |

Source: Primary Data

The findings suggest that farmers in Chimanimani District perceive several policy changes and interventions as crucial for promoting the wider adoption of conservation agriculture practices. Improved access to agricultural extension services and training is highlighted as a priority, emphasizing the importance of knowledge dissemination and capacity-building initiatives in

facilitating technology adoption (Thierfelder et al., 2017). Financial incentives or subsidies for adopting conservation agriculture practices are also seen as instrumental in offsetting initial investment costs and incentivizing farmers to transition to more sustainable farming methods (Lee & Gambiza, 2022). Strengthening land tenure security and property rights emerged as another key consideration, reflecting the significance of tenure arrangements in incentivizing long-term investments in soil conservation and land management (Tittonell et al., 2013). Additionally, infrastructure development, access to affordable inputs, and government support in marketing and value addition are identified as essential components of an enabling policy environment for conservation agriculture adoption, aligning with existing literature on the subject. Also the provision of government inputs on time before the start of the growing season was highlighted as another important intervention in conservation agriculture.

4.5 Qualitative Data

Table 8: Themes Generated

| Theme | Sub-themes | Frequency of Mention |
|-------------------------------------|--|-----------------------------|
| Access to Resources | Financial Support, Access to Equipment | 45 |
| Education and Training | Farmer Education Programs, Extension Services | 37 |
| Research and Development | Local Research Initiatives, Innovation Support | 19 |
| Market Access and Incentives | Market Linkages, Incentive Programs | 23 |
| Environmental Policies | Soil Health Regulations, Sustainable Water Use | 22 |
| Community and Social Support | Community Engagement, Peer Learning | 26 |

| | | |
|--|--|----|
| Policy Integration and Coordination | Inter-Departmental Coordination, Long-term Policy Planning | 18 |
|--|--|----|

Source: Primary Data

4.5.1 Access to resources

One of the most frequently mentioned factors influencing the adoption of conservation agriculture (CA) practices among farmers in Chimanimani District is the need for financial support. Respondents emphasized that the initial costs of implementing CA practices, such as purchasing conservation tillage equipment, cover crop seeds, and organic fertilizers, are prohibitively high. As one farmer noted,

"Without financial assistance, it's nearly impossible for small-scale farmers like us to invest in the necessary tools and inputs required for conservation agriculture."

This sentiment reflects a broader challenge where limited access to capital constrains farmers' ability to adopt sustainable agricultural practices. The need for financial support aligns with findings in the literature, where studies have shown that financial incentives, including subsidies, grants, and low-interest loans, are crucial for enabling farmers to overcome the initial cost barriers associated with CA (Knowler & Bradshaw, 2007). Furthermore, research indicates that financial support not only aids in the adoption of CA practices but also enhances farmers' capacity to sustain these practices over the long term (Lee & Gambiza, 2022). This highlights the critical role of financial mechanisms in fostering sustainable agriculture and improving food security in resource-constrained regions. Additionally, Mwangi and Kariuki (2015) emphasize that financial support must be coupled with other forms of assistance, such as training and extension services, to ensure the successful and sustained adoption of CA. This multifaceted approach helps to address both the economic and educational barriers that farmers face, thereby promoting more widespread and effective implementation of conservation agriculture.

4.5.2 Extension Services

Another significant theme emerging from the qualitative data is the importance of extension services in promoting the adoption of conservation agriculture (CA) practices. Farmers in Chimanimani District frequently mentioned that access to information, training, and ongoing support from agricultural extension officers is crucial for understanding and effectively implementing CA techniques. One farmer highlighted this by stating,

"The training sessions provided by the extension officers were invaluable. Without their guidance, I wouldn't have known how to properly integrate cover crops and manage soil health."

This perspective underscores the essential role that extension services play in bridging the knowledge gap and providing technical assistance to farmers. The critical role of extension services in the adoption of CA practices is well-documented in the literature. Studies have shown that effective extension services can significantly enhance farmers' knowledge and skills, thereby increasing the likelihood of adopting and sustaining CA practices. Osumba, Recha and Oroma (2021), extension services are vital in disseminating agricultural innovations and providing the necessary training and support to farmers. These services help farmers understand the benefits of CA, such as improved soil health and increased crop yields, and offer practical guidance on how to implement these practices effectively. Furthermore, extension services are essential for creating awareness and providing continuous support, which helps to overcome initial resistance to change and ensures the long-term success of CA practices. Oyetunde-Usman, Olagunju and Ogunpaimo (2021) found that farmers who had regular access to extension services were more likely to adopt and persist with sustainable agricultural practices compared to those who did not receive such support. This highlights the need for robust extension programs that are well-funded and accessible to all farmers, particularly in regions like Chimanimani District, where the adoption of CA can significantly contribute to sustainable agriculture and food security.

4.5.3 Local Research Initiatives

Another theme derived from the qualitative data is the role of local research initiatives in fostering the adoption of conservation agriculture (CA) practices. Farmers expressed a need for locally tailored research that addresses the specific challenges and conditions of their region. One participant remarked,

"We need more research done here in Chimanimani to understand how CA can work best for our soil and climate. It's not enough to rely on studies from other places."

The importance of local research initiatives is echoed in the broader literature on agricultural innovation and adoption. Research conducted in local contexts can provide more relevant and specific findings that are directly applicable to the farmers' unique environmental conditions and socio-economic settings. Hansen et al. (2019) emphasize that localized research helps in developing context-specific recommendations, which increases the relevance and effectiveness of

CA practices for the farmers in Chimanimani. Local research initiatives also enhance the credibility and trust of the findings among the farmers, leading to higher rates of adoption. When farmers see research being conducted in their own region, they are more likely to perceive the results as applicable to their circumstances. This sentiment is supported by research from Snapp and Pound (2017), who found that farmer participation in local research trials increases their willingness to adopt new practices because they can observe the outcomes firsthand.

4.5.4 Incentive Programs

The data also revealed the significant role of incentive programs in promoting the adoption of conservation agriculture (CA) practices. Farmers frequently mentioned the importance of financial incentives, subsidies, and access to low-interest loans as critical factors that motivate them to implement CA techniques. One participant stated,

"Without the financial support from the incentive programs, it would have been nearly impossible for me to switch to CA practices. The costs involved are high, and the returns are not immediate."

The findings align with existing literature that highlights the effectiveness of incentive programs in encouraging the adoption of sustainable agricultural practices. Financial incentives reduce the economic risks associated with transitioning to new farming methods, which is crucial for smallholder farmers who often operate with tight margins. Delaroche (2020), economic incentives are among the most effective tools for promoting the adoption of conservation practices. They argue that when farmers are provided with direct financial benefits, such as subsidies or payments for ecosystem services, they are more likely to adopt practices that might otherwise be perceived as too risky or costly. Bonjean (2019) emphasize that incentive programs can offset the initial costs of adopting new technologies and practices, thereby lowering the barriers to entry for farmers. These programs can include cost-sharing arrangements, tax breaks, or direct payments for adopting specific conservation practices.

4.5.5 Environmental Policies

The qualitative data highlighted a strong consensus among farmers regarding the need for supportive environmental policies to enhance the adoption of conservation agriculture (CA) practices. Many participants pointed out that current policies do not adequately address the unique challenges they face, such as access to water resources, soil degradation, and climate variability. One farmer remarked,

"The existing policies are not tailored to our needs as a whole. We need specific guidelines and support to improve soil health and manage water resources effectively."

The findings resonate with the broader literature on the role of environmental policies in promoting sustainable agricultural practices. Effective environmental policies are crucial for creating an enabling environment that supports farmers in adopting and maintaining CA techniques. Oyetunde-Usman, Olagunju and Ogunpaimo (2021), policies that are specifically designed to support sustainable agriculture can significantly enhance farmers' capacity to adopt conservation practices. These policies may include regulations that encourage the use of organic inputs, incentives for soil and water conservation, and measures to mitigate the impacts of climate change. Moreover, policy frameworks that integrate environmental sustainability with agricultural productivity are found to be more successful. Cataldo, Fucile and Mattii. (2021), noted that comprehensive policies that address multiple aspects of sustainability such as soil health, water management, and biodiversity are essential for the long-term success of CA practices. These policies not only provide the necessary support for farmers but also ensure that agricultural activities contribute positively to environmental conservation.

4.5.6 Community and Social Support

The qualitative data gathered from the survey reveals that community and social support play a crucial role in the adoption and sustained practice of conservation agriculture (CA) in Chimanimani District. Farmers frequently emphasized the importance of peer support, knowledge sharing, and the role of community leaders in encouraging and facilitating the transition to CA practices. One farmer shared,

"Seeing my neighbors successfully implement conservation agriculture gave me the confidence to try it myself. We regularly meet to discuss challenges and share solutions."

The findings align with the literature, which underscores the significance of community and social networks in the adoption of sustainable agricultural practices. Ogunleye et al., (2021) highlights that social capital defined as the networks of relationships among people who live and work in a particular society significantly influences farmers' decisions to adopt new agricultural technologies. The presence of strong community ties can enhance trust, reduce uncertainties, and provide a platform for sharing valuable information about CA practices.

4.5.7 Policy Integration and Coordination

The integration and coordination of policies are essential for the effective promotion and adoption of conservation agriculture (CA) practices. Survey responses indicated a need for cohesive and well-aligned policies that address various aspects of CA, including environmental sustainability, economic incentives, and agricultural support services. One respondent noted,

"Different policies need to work together seamlessly to provide the support we need for conservation agriculture."

This observation is consistent with findings in the literature, which highlight that fragmented and poorly coordinated policies can hinder the adoption of sustainable agricultural practices (FAO, 2010). Effective policy integration involves aligning agricultural, environmental, and economic policies to create a supportive framework that encourages CA practices. This includes harmonizing incentives for sustainable farming, ensuring consistent extension services, and fostering collaboration between governmental and non-governmental organizations. By coordinating policies and aligning them with the needs of farmers, governments can create an enabling environment that promotes the widespread adoption of CA practices, ultimately enhancing food security and environmental resilience (Sinclair et al., 2019).

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter synthesizes the research findings, evaluates the achievement of the research objectives, answers the research questions, and discusses the study's contributions and implications. Additionally, it offers practical recommendations for policymakers and managers, assesses the generalizability of the findings, acknowledges research limitations, and identifies areas for future research.

5.2 Summary

Chapter 1 established the foundation for the research, presenting the background and significance of conservation agriculture (CA) in enhancing agricultural productivity under rain-fed conditions. It introduced the primary problem which is low agricultural productivity and soil degradation in Chimanimani District due to environmental and socio-economic challenges. The chapter outlined the aim, research objectives, and key questions driving the study, situating CA as a potential solution. This chapter set the stage for the research by framing its relevance to sustainable agriculture and resilience in rural Zimbabwe.

Chapter 2 provided a comprehensive review of existing literature on CA, focusing on soil health, crop productivity, and socio-economic factors in rain-fed agricultural contexts. The literature review connected established theories of sustainable agriculture and agroecology to the study's objectives, highlighting empirical evidence of CA's benefits and challenges. By identifying research gaps, particularly the limited understanding of CA's impact in Chimanimani, this chapter established the theoretical and empirical foundation for the study, justifying the need for localized research.

Chapter 3 outlined the research design, methods, and approaches used to collect and analyze data. This chapter described the post-positivist paradigm and mixed-methods approach employed to capture both quantitative and qualitative data, ensuring a robust examination of CA's impact. It detailed the sampling methods, data collection techniques, and analytical tools, providing a rationale for each step. The methodology was designed to align with the research objectives and questions, ensuring methodological rigor and reliability in addressing the research problem.

Chapter 4 presented and analyzed the data collected from surveys and interviews with farmers in Chimanimani District. It detailed the demographic characteristics of respondents, the impact of

CA on soil health and crop yields, and socio-economic factors influencing CA adoption. Quantitative findings were illustrated with statistical analyses, while qualitative insights were explored through thematic analysis. This chapter provided a detailed interpretation of the data, connecting results to the research objectives and offering a nuanced view of CA's effectiveness in the study area.

Chapter 5 concluded the dissertation by synthesizing the key findings and assessing the extent to which research objectives were achieved. It summarized the study's contributions to understanding CA's role in promoting sustainable agriculture in Chimanimani, addressing gaps highlighted in the literature review. Policy recommendations were provided to improve CA adoption, including enhanced agricultural extension services, resource access, and supportive infrastructure. Limitations of the study and suggestions for future research were also discussed, emphasizing areas where further investigation could strengthen CA's impact on food security and resilience.

5.3 Conclusion

This study comprehensively evaluated the impact of conservation agriculture (CA) practices on soil health indicators, crop yields, and the socio-economic factors influencing their adoption among farmers in Chimanimani District. The findings reveal significant improvements in soil health and crop yields due to CA practices, confirming their efficacy in sustainable agriculture. The study also highlighted key socio-economic factors, such as access to resources and economic incentives, that drive the adoption of CA. Moreover, it identified critical gaps in current policies and provided targeted recommendations to enhance the support for CA, thereby promoting sustainable agriculture and improving food security in the region. By addressing these multifaceted aspects, the study not only achieved its research objectives but also contributed valuable insights for policymakers, practitioners, and researchers dedicated to advancing sustainable agricultural practices.

5.4 Contribution

5.4.1 Theoretical Contribution

This study contributes significantly to the theoretical understanding of conservation agriculture (CA) within the framework of sustainable agricultural practices. Firstly, it validates and extends the existing body of knowledge on the positive impacts of CA on soil health indicators and crop yields. Previous theoretical models suggested that CA practices, such as minimal soil disturbance, crop rotation, and permanent soil cover, can enhance soil organic matter, improve soil structure,

and increase water retention. Our findings empirically support these theories, showing measurable improvements in soil health and increased agricultural productivity. This alignment between theory and empirical evidence reinforces the robustness of CA as a sustainable agricultural model and provides a solid foundation for future theoretical explorations in this field.

Secondly, this study enriches the socio-economic theoretical frameworks that explore the adoption of agricultural innovations. By identifying key socio-economic factors such as access to resources, economic incentives, environmental concerns, and social pressures that influence farmers' decisions to adopt CA, the research provides a nuanced understanding of the adoption dynamics. The integration of these factors into the theoretical discourse highlights the multifaceted nature of agricultural innovation adoption. This comprehensive approach can help refine existing models and theories by incorporating the complex interplay between economic, social, and environmental drivers, thereby offering a more holistic perspective on the diffusion of sustainable agricultural practices.

5.4.2 Empirical Contribution

This study offers substantial empirical contributions by providing concrete data on the impacts of conservation agriculture (CA) practices on soil health and crop yields in the Chimanimani District. Through rigorous data collection and analysis, we observed significant improvements in soil health indicators such as increased organic matter, better soil structure, and enhanced water retention. Additionally, the adoption of CA practices led to notable increases in crop yields and overall agricultural productivity. These findings provide robust empirical evidence supporting the efficacy of CA in enhancing sustainable farming practices, particularly in rain-fed farming systems. Such data are crucial for policymakers, agricultural extension services, and farmers themselves, as they provide tangible proof of the benefits associated with CA practices, thereby encouraging wider adoption and implementation.

Furthermore, this research delves into the socio-economic factors influencing the adoption of CA practices, offering a detailed empirical analysis of the motivations and barriers faced by farmers in the region. By identifying critical factors such as access to resources, economic incentives, environmental concerns, and social pressures, the study provides valuable insights into the complex decision-making processes of farmers. This empirical evidence highlights the need for targeted interventions and support mechanisms to address these factors and promote the wider

adoption of CA. Additionally, by presenting data on farmers' perceptions of government policies and their recommendations for policy changes, the study offers actionable insights for policymakers aimed at fostering a more supportive environment for sustainable agriculture. This empirical contribution not only enriches the existing literature but also serves as a practical guide for future policy and program development in the region.

5.4.3 Methodological Contribution

The methodological contribution of this study lies in its comprehensive approach to data collection and analysis, which integrates both quantitative and qualitative methods to provide a holistic understanding of conservation agriculture (CA) practices in the Chimanimani District. By utilizing structured questionnaires to gather quantitative data on soil health indicators, crop yields, and socio-economic factors, alongside open-ended questions to capture qualitative insights from farmers, the study ensures a robust triangulation of data. This mixed-methods approach not only enhances the reliability and validity of the findings but also allows for a deeper exploration of the nuanced factors influencing the adoption of CA practices. Additionally, the application of statistical tests and thematic analysis further strengthens the methodological rigor, providing a replicable framework for future research on sustainable agricultural practices.

5.5 Practical policy contributions

The findings of this study offer valuable insights for policymakers aiming to promote the wider adoption of conservation agriculture (CA) practices in the Chimanimani District and similar agricultural regions. Firstly, there is a pressing need for the development and implementation of supportive policies that incentivize smallholder farmers to transition to CA methods. This could include financial incentives such as subsidies for the purchase of conservation agriculture equipment, as well as technical assistance and training programs to build farmers' capacity in implementing sustainable farming practices. Moreover, policymakers should prioritize the dissemination of information and knowledge about the benefits of CA through targeted extension services and farmer education programs. By raising awareness and providing technical support, policymakers can facilitate the adoption of CA among smallholder farmers, ultimately contributing to improved soil health, increased crop yields, and enhanced food security.

Secondly, there is a critical role for policy integration and coordination across different sectors to address the multifaceted challenges facing smallholder farmers in adopting CA practices. This entails aligning agricultural policies with broader environmental conservation and rural

development strategies to ensure coherence and synergy in implementation efforts. Policymakers should collaborate with relevant stakeholders, including government agencies, non-governmental organizations, research institutions, and local communities, to develop integrated policy frameworks that promote sustainable agriculture while addressing socio-economic inequalities and environmental degradation. By fostering collaboration and coordination among stakeholders, policymakers can leverage resources more effectively and enhance the impact of CA initiatives on rural livelihoods and ecosystem resilience.

Furthermore, policymakers should prioritize the development of supportive infrastructure and market linkages to facilitate the adoption and scaling up of CA practices among smallholder farmers. This includes investment in rural infrastructure such as roads, irrigation systems, and storage facilities to improve access to markets and reduce post-harvest losses. Additionally, policymakers should explore innovative financing mechanisms, such as revolving funds and microcredit schemes, to provide farmers with affordable access to inputs and resources needed for CA implementation. By addressing barriers related to access to markets and financial resources, policymakers can create an enabling environment for smallholder farmers to adopt and sustain CA practices, thereby contributing to long-term agricultural sustainability and resilience in the Chimanimani District.

5.6 Practical Managerial recommendations

The managerial implications of this study extend beyond policy recommendations to actionable strategies for agricultural stakeholders, including farmers, agricultural extension agents, and agricultural cooperatives, to enhance the adoption and implementation of conservation agriculture (CA) practices in the Chimanimani District. Firstly, agricultural extension services play a crucial role in providing technical assistance, training, and knowledge dissemination to farmers. Extension agents should be equipped with up-to-date information on CA practices and trained in participatory extension methodologies to effectively engage with smallholder farmers. Moreover, extension services should prioritize the establishment of demonstration plots and farmer field schools to showcase the benefits of CA and provide hands-on training to farmers, fostering learning-by-doing and peer-to-peer knowledge exchange.

Secondly, agricultural cooperatives and farmer organizations can serve as important intermediaries for promoting CA adoption and facilitating collective action among smallholder farmers.

Cooperatives can leverage their collective bargaining power to negotiate better prices for agricultural inputs and access to markets, reducing transaction costs and improving farmers' profitability. Additionally, farmer organizations can play a key role in mobilizing resources, organizing training programs, and advocating for supportive policies at the local and national levels. By strengthening the capacity of agricultural cooperatives and farmer organizations, managers can empower smallholder farmers to adopt CA practices more effectively and sustainably.

Furthermore, there is a need for investment in agricultural research and innovation to develop context-specific solutions and technologies that address the unique challenges faced by smallholder farmers in rain-fed farming systems. Research institutions and agricultural agencies should prioritize applied research on CA practices, focusing on adaptation strategies, soil fertility management, and crop diversification to enhance resilience to climate change and variability. Additionally, there is a need for collaborative research initiatives involving multidisciplinary teams of scientists, agronomists, sociologists, and economists to co-create knowledge and develop holistic approaches to sustainable agricultural development. By fostering innovation and knowledge-sharing, agricultural managers can drive continuous improvement and adaptation in CA practices, ensuring their relevance and effectiveness in addressing the evolving needs of smallholder farmers in the Chimanimani District and beyond.

5.7 Generalization of findings

Generalization of the findings from this study to other contexts requires careful consideration of the specific socio-economic, agro-ecological, and institutional factors that shape agricultural practices and outcomes. While the results of this study provide valuable insights into the impacts of conservation agriculture (CA) practices in the Chimanimani District under rain-fed conditions, they may not be directly applicable to all agricultural settings. However, the underlying principles and key lessons derived from this research can inform broader discussions and interventions aimed at promoting sustainable agriculture and enhancing food security in similar agro-ecological zones and socio-economic contexts. For instance, the importance of soil health indicators and crop yield improvements observed in this study underscores the potential benefits of CA practices in enhancing agricultural productivity and resilience to climate change across diverse farming systems. Additionally, the socio-economic factors influencing the adoption of CA, such as access to resources and economic incentives, highlight the need for targeted interventions and policy

support to address barriers and promote the widespread adoption of sustainable agricultural practices. By contextualizing the findings within broader theoretical frameworks and engaging with stakeholders at various levels, policymakers, researchers, and practitioners can leverage the insights gained from this study to design context-specific interventions and strategies that promote sustainable agricultural development and contribute to achieving global food security goals.

5.8 Research Limitations

Despite the comprehensive nature of this study, several limitations should be acknowledged. Firstly, the reliance on self-reported data from farmers may introduce response bias and social desirability bias, potentially influencing the accuracy and reliability of the findings. While efforts were made to minimize these biases through careful questionnaire design and data collection procedures, the subjective nature of some responses may still affect the robustness of the results. Additionally, the cross-sectional design of the study limits the ability to establish causal relationships between conservation agriculture practices and observed outcomes. While the natural experiment approach adopted in this study enabled comparisons between farmers practicing CA and those using conventional methods, longitudinal studies or controlled trials would provide stronger evidence of causality.

Furthermore, the generalizability of the findings may be limited by the specific context of Chimanimani District and the characteristics of the study population. Factors such as agro-ecological conditions, socio-economic dynamics, and institutional arrangements vary across different regions, influencing the adoption and impact of conservation agriculture practices. Therefore, caution should be exercised when extrapolating the results to other settings, and future research should aim to replicate the study in diverse agro-ecological zones and socio-economic contexts to enhance the validity and generalizability of the findings. Additionally, the sample size of the study, while sufficient for statistical analysis, may not fully represent the diversity of smallholder farmers in Chimanimani District, potentially limiting the breadth of perspectives captured. Future studies could benefit from larger sample sizes and more extensive sampling strategies to ensure greater representation and diversity within the study population, thereby enriching the analysis and enhancing the relevance of the findings.

5.9 Areas of further research

Building on the insights gained from this study, several avenues for further research emerge, offering opportunities to deepen our understanding of conservation agriculture and its implications for sustainable agricultural development. Firstly, longitudinal studies are warranted to investigate the long-term effects of conservation agriculture practices on soil health, crop yields, and farmers' livelihoods. By tracking changes in key indicators over multiple seasons or years, researchers can assess the sustainability and resilience of CA systems, elucidating the dynamics of soil-plant interactions and the cumulative benefits of conservation practices over time.

Secondly, there is a need for research that explores the socio-economic determinants of conservation agriculture adoption in greater depth, particularly focusing on the role of institutional support, market access, and farmer perceptions. Qualitative studies employing in-depth interviews and participatory approaches could provide valuable insights into the decision-making processes of smallholder farmers, shedding light on the barriers and facilitators to CA adoption and implementation. Understanding the nuanced socio-economic context in which farmers operate is essential for designing targeted interventions and policies that effectively promote the uptake of sustainable agricultural practices.

Lastly, comparative studies across different agro-ecological zones and socio-economic contexts would enrich our understanding of the contextual factors shaping the adoption and impact of conservation agriculture. By examining variations in CA adoption rates, agronomic practices, and outcomes across diverse settings, researchers can identify region-specific challenges and opportunities, as well as transferable lessons and best practices. Comparative research could also explore the interaction between conservation agriculture and climate change adaptation strategies, elucidating the synergies and trade-offs between sustainable land management practices and resilience-building measures in the face of environmental uncertainty. Overall, these areas of further research hold promise for advancing knowledge and informing evidence-based policies and interventions aimed at promoting sustainable agriculture and enhancing food security in diverse contexts.

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QUESTIONNAIRE

BACKGROUND

My name is Martin Karinda and I am conducting a research study to find the effects of conservation agriculture under rain fed conditions in Chimanimani District. Your valuable insights can significantly contribute to the understanding of this complex issue and help create effective efforts in agriculture practices that sustain local people.

Confidentiality

I want to assure you that all information shared during the process will be treated with the utmost confidentiality. Your privacy is of the highest importance, and your responses will only be used for research purposes.

Please put ticks in the box provided and write your answers in the space provided.

SECTION A: PERSONAL INFORMATION

1. Gender

Male

Female

2. Age.....

3. Academic and Professional Qualification

| | | | |
|-----------------------|--------------------------|-----------|--------------------------|
| Primary | <input type="checkbox"/> | Secondary | <input type="checkbox"/> |
| No school certificate | <input type="checkbox"/> | Tertiary | <input type="checkbox"/> |

4. Household Size.....

Section B: Farming Practices

5. How many years have you been practicing agriculture in Chimanimani District?
.....

6. What type of farming practices do you primarily engage in?

Conservation Agriculture

Conventional Agriculture

Other (Specify).....

7. What motivated you to adopt your current farming practices? (Open-ended)

.....
.....

Section 3: Conservation Agriculture Experience

8. Have you received any training or extension services on conservation agriculture?

Yes

No

9.

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Please rate your level of knowledge about conservation agriculture. | | | | | |

1. Less knowledge

2. More knowledge

10. What challenges have you encountered in practicing conservation agriculture?
(Open-ended)

.....
.....

Section D: Agricultural Productivity

11. What is your average annual maize yield per hectare (kg)?.....

12. How do you perceive the productivity of your farm compared to five years ago?

Less productive

Moderately productive

Highly productive

13. What factors do you believe contribute most to agricultural productivity in
Chimanimani District?

Soil Fertility

Water Availability

Access to Inputs

Climate Conditions
Other (please specify) _____

Section E: Livelihood sustainability

14. How would you rate your household's food security status?

Insecure

Moderately Insecure

Secure

15. What income-generating activities, other than farming, does your household engage in? (Open-ended)

.....
.....

16. How do you perceive the long-term sustainability of your current farming practices?

Not sustainable

Moderately sustainable

Sustainable

Section F: Suggestions and feedback

17. What support or interventions do you think would help improve agricultural productivity and livelihood sustainability in Chimanimani District? (Open-ended)

.....
.....

18. Any additional comments or feedback you would like to share? (Open-ended)

.....
.....

Thank you for your cooperation!

Appendix 2: Plagiarism Results

| KARINDA FINAL | | | |
|--------------------|--|--------------|----------------|
| ORIGINALITY REPORT | | | |
| 5% | 1% | 4% | 0% |
| SIMILARITY INDEX | INTERNET SOURCES | PUBLICATIONS | STUDENT PAPERS |
| PRIMARY SOURCES | | | |
| 1 | "Conservation Agriculture: A Sustainable Approach for Soil Health and Food Security", Springer Science and Business Media LLC, 2021 Publication | 2% | |
| 2 | www.agrifoodmagazine.co.in Internet Source | 1% | |
| 3 | "Food Security for African Smallholder Farmers", Springer Science and Business Media LLC, 2022 Publication | 1% | |
| 4 | Tendai Kaponda, Option T. Chiwaridzo. "chapter 11 Enhancing Food Security Through Sustainable Agriculture", IGI Global, 2024 Publication | 1% | |
| 5 | Innovations as Key to the Green Revolution in Africa, 2011. Publication | 1% | |
| 6 | fastercapital.com Internet Source | 1% | |

