An evaluation of the uptake of Conservation Agriculture practices among smallholder farmers: A case for Mudzi District in Mashonaland East Province.

A dissertation submitted in partial fulfilment of the requirements for the Master of Science Degree in Food Security and Sustainable Agriculture (Policy Option)

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Department of Agricultural Economics. Education and Extension

BY

ROBERT JAMU

[B213230B]

SUPERVISOR: MR GOVERE. I.

MAY 2023

RELEASE FORM

NAME OF AUTHOR:	**ROBERT JAMU**
REG NBUMBER:	**B213230B**
TITLE OF PROJECT:	**An evaluation of the uptake of Conservation Agriculture practices among smallholder farmers: A case for Mudzi District in Mashonaland East Province**
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Name of supervisor: Mr. I. Govere

Signature: ……..

Date: 16 May 2023

DECLARATION

I Robert Jamu (B213230B) hereby declare that the research project entitled "**An evaluation of the uptake of Conservation Agriculture practices among smallholder farmers: A case for Mudzi District in Mashonaland East Province**" submitted to Bindura University of Science Education, Department of Agricultural Economics, Education and Extension is a record of an original work done by me under the guidance and supervision of Mr. I. Govere and this work is submitted in partial fulfilment of the requirements for the award of a Master of Science Degree in Food Security and Sustainable Agriculture. The results embodied in this thesis have not been submitted to any University or Institute for the award of any degree of diploma.

Author: Robert Jamu

Reg Number: B213230B

Signature:

Date: 16 May 2023

DEDICATION

This research is dedicated to my Parents, Mr and Mrs. Jamu. Thank you for imparting the concept of hard work in me.

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I would like to extend my heartfelt gratitude to Mr. Govere my Supervisor for patiently steering me towards the successful completion of this study. I would also want to thank the participants without whose contributions this study would have been successful.

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ABSTRACT

The study explores the uptake of Conservation Agriculture practices among smallholder farmers in Mudzi District in Mashonaland East Province. The adoption of conservation agriculture is increasingly becoming important in southern Africa to sustainably increase food security, manage degraded lands and increasing resilience of agricultural systems to climate change. The practices is relevant to the smallholder farming systems of Zimbabwe where productivity is constrained by lack of access to agricultural inputs, decline in soil fertility and increasing rainfall variability. However despite years of research and extension, the adoption of the practice is very limited and piecemeal in Zimbabwe. Therefore, the main objective of the research was to get an in depth understanding of the barriers to adoption of conservation agriculture in Zimbabwe with specific reference to smallholder farmers. The study employed participatory approaches to collect data in Mudzi districts. A pre-tested questionnaire was administered to three selected wards in Mudzi District. The questionnaire was triangulated through focus group discussions, key informant interviews and personal observations in order to enhance the richness of our findings. Household survey data was analysed using Statistical Packages for Social Scientists and Statistical Analysis Software, while information obtained during key informant interviews and focus discussions was analysed through thematic analysis. Results revealed that despite agriculture contributing to the livelihoods of the majority of the smallholder farmers, less than 10% of the respondents had any formal agricultural training. On the other hand, the level of knowledge on conservation agriculture was high amongst the respondents. However, the non-adopters had an indifferent perception about the technology. The significant ($P<0.05$) explanatory variables of the knowledge attribute were age, gender, education, visit to demonstration centres and years of practicing the technology, while the perception attribute was explained by age, gender, education, visit to demo sites, experience in conservation agriculture and agriculture. On the other hand, the study found a weak but significant correlation between knowledge and perception ($R_s = 0.36$, $P < 0.05$), knowledge and adoption ($R_s = 0.484$, $P < 0.05$) but strong and significant correlation between perception and adoption ($R_s = 0.808$, $P < 0.05$). The later points to a very important point, that adoption of conservation agriculture can be improved by increasing positive perception of the farmers towards the technology. It was also established that the respondents adopted conservation agriculture through the knowledge (mean score of 2.13; standard error = 0.043)) and compliance (mean score of 2.02; standard error = 0.043) pathways. The explanatory variables of the knowledge pathway were education, experience in agriculture, agricultural training and visit to demonstration centers while the gender of the household was the significant variable in explaining the compliance pathway. The study recommends closing negative perception gaps, understanding appropriate adoption pathways in the promotion of conservation agriculture and providing guidelines on "true" conservation agriculture, linking farmers to markets and improved access to conservation agriculture equipment as the main drivers of adoption of the technology among smallholder farmers in Zimbabwe.

Key words: *Conservation argriculture ; small holder farmers; uptake, evaluation*

LIST OF ACRONYMS AND ABBREVIATIONS

AEZ	-	Agro-Ecnomic Zone
AGRITEX	-	Agriculture Research and Extension Services
CA	-	Conswervation Agriculture
CFUZ	-	Commercial Famers Union of Zimbabwe
GHG	-	Green Houses Gases
RDC	-	Rural District Council
FAO	-	Food and Agriculture Organisation

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CHAPTER 1

INTRODUCTION

1.0 Introduction

This chapter introduces the foundation of the whole research through important components of the study. It covers the background of the study, statement of the problem and the objectives. Problem statement will give information on what exactly is the problem behind the study. Background of the study will give a wide overview on the study explaining its history. The objective will give a statement on what the study intends to achieve. Other components which are going to be covered under this chapter are research questions, significance of the study, assumptions, delimitation, limitations and definitions of key terms. These components will guide the study as a whole and will give the reader an insight on what is to follow in other chapters.

1.1 Background of the Study

FAO (2019:12) allude that “Conservation Agriculture is a farming system that promotes maintenance of a permanent soil cover, minimum soil disturbance, and diversification of plant species. It enhances biodiversity and natural biological processes above and below the ground surface, which contribute to increased water and nutrient use efficiency and to improved and sustained crop production." Conservation Agriculture is included among the incremental adaptation options to address climate risks. The three main principles of conservation agriculture (minimum soil disturbance, crop diversification, and permanent soil cover) help to protect the environment and to reduce both the impacts of climate change on agricultural systems (adaptation) and the contribution of the agricultural practices to greenhouse gases (GHG) emissions (mitigation) through sustainable land management, (IPCC 2019).

Globally, the conservative farming practices have been advocated for more than seven decades yet remaining at low adoption. CA involves changing many conventional farming practices as well as the mindset of farmers to overcome the conventional use of tillage operations. Although adoption of CA is increasing globally, in some regions it is either slow or non-existent. The adoption of CA has both agricultural and environmental benefits but there is a lack of information on the effects and interactions of key CA components which affect yield and hinder its adoption.

The global empirical evidence shows that farmer-led transformation of agricultural production systems based on Conservation Agriculture (CA) principles is already occurring and gathering momentum worldwide as a new paradigm for the 21st century. The data presented in this study, mainly based on estimates made by farmer organizations, agro-industry, and well-informed individuals provide an overview of CA adoption and spread by country, as well as the extent of CA adoption by continent. CA systems, comprising minimum mechanical soil disturbance, organic mulch cover , and crop species diversification, in conjunction with other good practices of crop and production management, are now practiced globally on about 125 M ha in all continents and all agricultural ecologies, including in the various temperate environments.

Tillage, particularly in fragile ecosystems, was questioned for the first time in the 1930s, when the dustbowls devastated wide areas of the mid-west United States. Concepts for reducing tillage and keeping soil covered came up and the term conservation tillage was introduced to reflect such practices aimed at soil protection. But it was not until the 1960s for no-tillage to enter into farming practice in the USA. In the early 1970s no-tillage farming reached Brazil, where farmers together with scientists transformed the technology into the system which today is called CA. No-tillage and mulching were also tested in the 1970s in West Africa (Greenland, 2019).

In Zimbabwe communal farming is characterised by low and inadequate soil, land and crop management techniques. In many cases land preparation is of a low standard, planting is often delayed and crops are not well managed. Conservation agriculture is an appropriate

technology that can address some of the underlying crop management problems facing farming in the sub region. When practised to a high standard it can significantly boost production, and improve the food security and livelihoods of farming households, (Zimbabwe Conservation Agriculture Task Force, 2009).

The last few seasons have seen the introduction of Conservation Agriculture to small holder farmers in Zimbabwe. In many cases yields have been remarkable with farmers practising conservation agriculture able to double or sometimes triple yields compared to those farmers not practising conservation agriculture.

Climate change refers to the increase in greenhouse gas emissions (GHGs) such as nitrous oxide (N2O), carbon dioxide (CO2) and methane (CH4) in the atmosphere causing irregularity, variability and unpredictability of rainfall, temperature increase , floods and drought. These effects will likely be "severe, pervasive, and irreversible" in the years to come, and the African continent seems to be one of the most vulnerable zones across the globe (Meyer and Masson - Delmotte, 2021).

It is now generally accepted that climate change is a crisis of global proportions, and that it poses unprecedented challenges to rain-fed agriculture . Climate change has compromised the livelihoods and food security of millions of people. Smallholder farmers in Zimbabwe have not been exempt from the disruptive and negative effects of climate challenge (Chitongo & Casadevall, 2019; Dube et al., 2016; Murray et al., 2016). Of note is the fact that 67% of the Zimbabwean populace depends on agriculture for income and sustenance (World Bank, 2019a). Successive droughts have meant that Zimbabwe is currently facing its worst humanitarian crisis in decades with over 5.5 million rural people food insecure (Zimbabwe Vulnerability Assessment Committee (ZimVAC,).

Conservation agriculture is a sustainable, transformative and technologically innovative approach to farming that has been developed to mitigate the effects of climate change (Taylor, 2018). CA is meant to enhance food security using environment - friendly farming practices, technologies, and inputs. It is composed of three main pillars, which is sustainable increment of agricultural productivity, bolstering resilience and reducing greenhouse

emissions (Abegunde et al., 2019). Conservative agriculture bolsters the resilience of agricultural systems and seeks to achieve a balance between the priorities of adaptation, mitigation , and food security (Thornton et al., 2018).

The persistent change in rainfall and temperature patterns threatens agricultural production and exacerbates the vulnerability of those who rely on rain-fed agriculture for their livelihoods (United Nations Framework Convention on Climate Change (UNFCC), 2019; Dube & Phiri, 2013; Dube et al., 2021). Climate change disrupts food markets, putting a larger population at risk of food insecurity, particularly resource-poor smallholder farmers (Intergovernmental Panel on Climate Change. (IPCC), 2019).

In light of the aforementioned, the study investigates the low uptake of conservative Agriculture by smallholder farmers in Mudzi District. Mudzi District was selected after due consideration of a number of aspects. Zimbabwe, as a country, is divided into Natural Farming Regions (NRs) also referred to as Agro-ecological zones. These demarcations are based on average annual precipitation levels , soil type and other climatic factors. There are five of these regions with NR I receiving the highest precipitation amounts and favorable climatic for farming conditions while NR V is the most arid. Mudzi falls in NR 4 and 5. The main source of livelihood for the district's inhabitants is agriculture. For this reason, carrying out the investigation in these NRs may provide an opportunity for an objective assessment. Secondly a lot of effort needs to be invested to develop these CA programs. Lastly, the researcher has good rapport with the key players in the district such that access challenges are minimal.

1.2 Statement of the Problem

Globally, Conservation Agriculture (CA) principles is already occurring and gathering momentum worldwide as a new paradigm for the 21st century. CA systems, comprising minimum mechanical soil disturbance, organic mulch cover, and crop species diversification, in conjunction with other good practices of crop and production management , are now practiced globally on about 125 M ha in all continent. Back home, while conservation agriculture is proposed as an important means to combat climate change, improve crop

productivity and food affordability, and to protect the environment, the adoption of conservation agriculture in Zimbabwe, Africa in general has been broadly, been low and slow. It is against this background that the researcher set to evaluate the low uptake of Conservation Agriculture practices among smallholder farmers in Mudzi District, Mashonaland East Province.

1.3.1 Main Objective

An evaluation of the low uptake of conservation agriculture practices among small holder farmers in Mudzi District.

1.3.2 Objectives

- To investigate the behaviour of smallholder farmers towards adoption of CA.
- To identify the reasons for the low uptake of conservation agriculture practices in Mudzi District
- To investigate the significant pathways of CA adoption among smallholder farmers

1.4 Research Questions

- What is the behaviour of smallholder farmers towards adoption of CA?
- What are the reasons for the low uptake of conservation agriculture practices in Mudzi District?
- What are the the significant pathways of CA adoption among smallholder farmers?

1.5 Justification of the study

This is an empirical study, that is, one backed by evidence. Previous studies related to the study in the country have been mainly theoretical. The study is going to be of great importance as it is going to fill the knowledge gap that exists on the current body of knowledge. Currently, it is only known that there are CA programs being employed in the country but the reason of their low uptake is not known hence this research is going to shed more light on the state of CA practices in Mudzi District.

In addition to that, the Government of Zimbabwe and other responsible authorities will be made aware of the CA practices currently being utilized in Mudzi District.

More so, the study will also be of great importance in the academic field. It is going to be published and will be used for literature review purposes by other researchers who will be doing related studies and is going to trigger more researches as far as Conservation agriculture programs are concerned.

1.6 Delimitation of the study

The study focuses on only the evaluation the low uptake of Conservation agriculture practices being employed by smallholder farmers in Mudzi District. Precisely, a small sample of 10 villages were covered. Thus, only views of primary respondents from 10 villages in Mudzi district shape the findings of the study.

1.7 Outline of thesis

The research was split into six distinct sections which are:

Chapter 1 - The first chapter outlines the background to the study, research objectives, research questions and the statement of the problem. It also highlights justification of the study limitations and delimitations of the study. **Chapter 2 -** This chapter reviews the relevant literature , outlines the theoretical background and conceptual framework laying the foundation for the research. It outlines the contributions of previous researchers and authors to the field under study. **Chapter 3 -** The third chapter focuses on the research methodology, that is , the approach and strategy employed by the researcher in gathering data, data analysis as well as limitations encountered in the course of the research. **Chapter 4 -** The chapter presents results for obejctives 1 and obejctive 2. The disucssion of the results are also contained in the same chapter. **Chapter 5 –** The chapter dicuses results for objective 3. Inferences wil be made in rlation to literature and the study findings. **Chapter 6 -** The fist chapter summarizes and draws conclusions as well as recommendations of the study. The chapter also details the actions to be undertaken so as to improve change management .

1.8 Chapter Summary

This chapter has provided the reader with background information of the study area; statement of the problem, aims and intentions, research questions. The delimitation of the study, definition of terms and the contribution of the study has also been articulated. The final section of the chapter indicated the organization of the study. The next chapter focusses on the review of literature related to Conservation agriculture.

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CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Conservation Agriculture is characterised by minimal soil disturbance, diversified crop rotations, and surface crop residue retention to reduce soil and environmental degradation while sustaining crop production, (Muhammad et al 2015). CA involves changing many conventional farming practices as well as the mindset of farmers to overcome the conventional use of tillage operations.

Conservation Agriculture (CA) is a farming system that can prevent losses of arable land while regenerating degraded lands. It promotes maintenance of a permanent soil cover, minimum soil disturbance, and diversification of plant species. It enhances biodiversity and natural biological processes above and below the ground surface, which contribute to increased water and nutrient use efficiency and to improved and sustained crop production (FAO 2020). The has Conservation Agriculture (CA) has potential changes to soil physical. Chemical and biological soil quality parameters compared to conventional tillage (CT) systems, (Jetinder et al 2020, Dechang et al 2022).

CA principles are universally applicable to all agricultural landscapes and land uses with locally adapted practices. Soil interventions such as mechanical soil disturbance are reduced to an absolute minimum or avoided, and external inputs such as agrochemicals and plant nutrients of mineral or organic origin are applied optimally and in ways and quantities that do not interfere with, or disrupt, the biological processes. (FAO, 2020, Deepak, 2020).

According to FAO, Conservation Agriculture (CA) is an approach to managing agro-ecosystems for improved and sustained productivity, increased profits and food security while preserving and enhancing the resource base and the environment. CA is characterized by three linked principles, namely: 1 Continuous no- or minimal mechanical soil disturbance (i.e., no-tillage and direct sowing or broadcasting of crop seeds, and direct placing of planting material in the soil; minimum soil disturbance from cultivation, harvest operation

or farm traffic, in special cases limited strip tillage); 2 Permanent organic soil cover, especially by crop residues, crops and cover crops; and 3 Diversification of crop species grown in sequence or associations through rotations or, in case of perennial crops, associations of plants, including a balanced mix of legume and non-legume crops CA principles are universally applicable to all agricultural landscapes and land uses with locally adapted practices. CA enhances biodiversity and natural biological processes above and below the ground surface (Friedrich et al, 2019).

CA facilitates good agronomy, such as timely operations, and improves overall land husbandry for rain-fed and irrigated production. Complemented by other known good practices, including the use of quality seeds, and integrated pest, nutrient, weed and water management, etc., CA is a base for sustainable agricultural production intensification. It opens increased options for integration of production sectors, such as crop-livestock integration and the integration of trees and pastures into agricultural landscapes. (FAO 2020, Deepak, 2020).

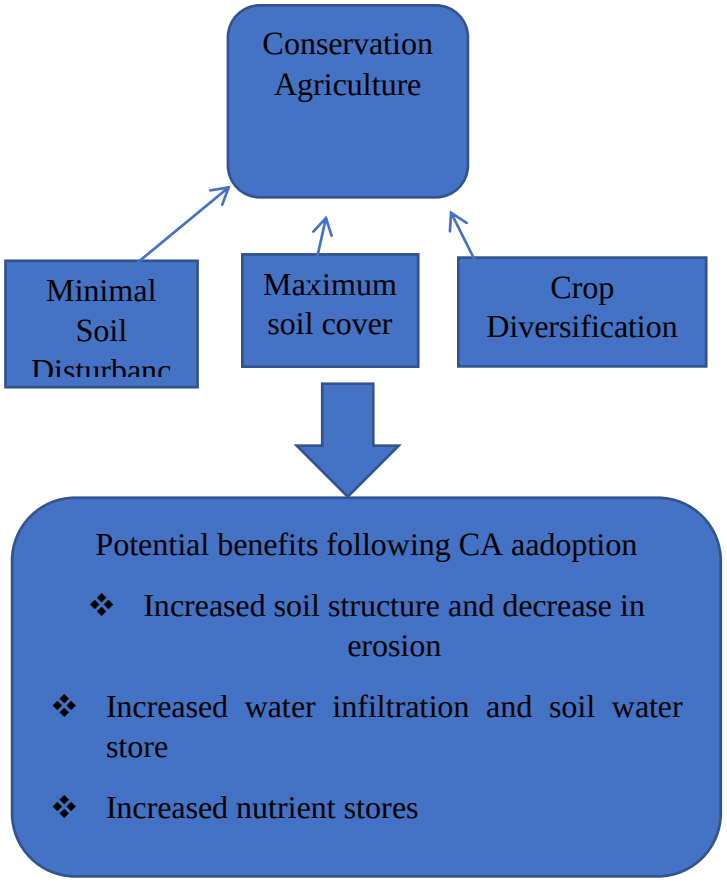
Globally, food insecurity is a huge challenge, especially among developing nations. The severity of the problem varies from one continent to the other. Development practitioners, researchers, government leaders and scientists are struggling to come up with a sustainable solution in addressing food insecurity, (Jatinder 2020). Conservation agriculture (CA), which is a concept for resource-saving agriculture crop farming system that strives to achieve acceptable profits together with high and sustained production level while concurrently conserving the environment is one of the potential remedy to food shortage. CA is characterized by three major principles minimum soil tillage, soil cover (mulch) and crop rotation.

CA is widely perceived as one way of sustainably addressing food insecurity not only in Africa but also in other developing countries globally. Research has shown that CA when properly practised can lead to increased yield, improved soil structure and increased utilization of agricultural resources. Despite CA's numerous benefits, some farmers in developing nations are reluctant to adopt the farming system (Mina et al 2022).

The reasons behind this are immense and diverse and this study aimed to achieve the following objectives: (i) to assess why there is low uptake of CA, (ii). to assess contribution of CA to food security (iii). to recommend strategies and appropriate approaches in resolving food insecurity.

Conservation Agriculture (CA) approach was introduced to manage agro-ecosystems for improved and sustained productivity, and increased farmers' profits while maintaining the natural resources, (Mina et al 2022). This comprises the management of natural resources at the farm, village, and landscape scales to increase synergies between food production and ecosystem conservation.

Keywords: *Sustainability, Conservation Agriculture, Food Security, Smallholder farmers,* Household



Concept of Conservation Agriculture

2.2 The History of Conservation Agriculture

The global empirical evidence shows that farmer-led transformation of agricultural production systems based on Conservation Agriculture (CA) principles is already occurring and gathering momentum worldwide as a new paradigm for the 21st century, (Friedrich et al, 2012).

CA began as a product of the twin disasters of the 1930's in the United States, the Dust Bowl and the Great Depression. (Coppess 2017). The Dust bowl period was a time of severe droughts that lasted from 1930 to 1936 in the United States. The term Dust Bowl was suggested by conditions that struck the region prior to productive seasons of wheat produce. Following years of overcultivation and generally poor land management in the 1920s, the region suffered a severe drought in the early 1930s that lasted several years. (Alexander, Robert et al 2018) In concert with the economic catastrophe of the Great Depression, the Dust Bowl was responsible for numerous deaths and unprecedented migration away from the region.

Consequently, concepts for reducing tillage and keeping soil covered came up and the term conservation tillage was introduced to reflect such practices aimed at soil protection. Seeding machinery developments allowed then, in the 1940s, to seed directly without any soil tillage.

But it was not until the 1960s for no-tillage to enter into farming practice in the USA. In the early 1970s no-tillage farming reached Brazil, where farmers together with scientists transformed the technology into the system which today is called CA , (Alexander, Robert et al 2018). No-tillage and mulching were also tested in the 1970s in West Africa (Nick Jones, 1969). Yet it took some 20 years before CA reached significant adoption levels in South America and elsewhere . During this time farm equipment and agronomic practices in no-tillage systems were improved and developed to optimize the performance of crops, machinery and field operations. This process is still far from being over as the creativity of farmers and researchers is still producing improvements to the benefits of the system, the soil and the farmer. From the early 1990s CA began to spread exponentially, leading to a

revolution initially in the agriculture of southern Brazil, Argentina and Paraguay. During the 1990s this development increasingly attracted attention from other parts of the world, including development and international research organizations such as FAO, CIRAD and some CGIAR centres. Study tours to Brazil for farmers and policy makers, regional workshops, development and research projects were organized in different parts of the world leading to increased levels of awareness and adoption in a number of African countries such as Zambia, Tanzania and Kenya as well as in Asia, particularly in Kazakhstan and China. The improvement of conservation tillage and no-tillage practices within an integrated farming concept such as CA also led to increased adoption, including in industrialized countries, after the end of the millennium, particularly in Canada, Australia, Spain and Finland. CA crop production systems are experiencing increased interest in most countries around the world. There are only few countries where CA is not practiced by at least some farmers and where there are no local research results available about (Friedrich et al, 2018).

2.3 Conservation Agriculture and Climate Change.

Agricultural productivity growth is vital for economic and food security outcomes which are threatened by climate change. In response, governments and development agencies are encouraging the adoption of 'climate-smart' agricultural technologies, such as conservation agriculture (CA) (Jeffrey, et al 2019).

Agriculture is extremely vulnerable to climate change. Climate change's negative impacts are already being felt, in the form of increasing temperatures, weather variability, shifting agroecosystem boundaries, invasive crops and pests, and more frequent extreme weather events. On farms, climate change is reducing crop yields, the nutritional quality of major cereals, and lowering livestock productivity. Substantial investments in adaptation will be required to maintain current yields and to achieve production and food quality increases to meet demand (World Bank, 2021).

The problem also works in reverse. Agriculture is a major part of the climate problem. It currently generates 19 –29 % of total greenhouse gas (GHG) emissions. Without action, that percentage could rise substantially as other sectors reduce their emissions.

While not yet universally accepted, it is now widely believed that anthropogenic emissions of carbon dioxide and other greenhouse gases have the potential to substantially warm climates worldwide (Kaiser, 2011). The yields of different crops and geographic limits nutrients, the crop species, temperature, precipitation and may be altered by changes in soil moisture, temperature, other environmental factors.

Climate is the primary determinant of agricultural productivity. Concern over the potential effects of long-term climatic change on agriculture has motivated a substantial body of research over the past decade. This body of research addresses possible physical effects of climatic change on agriculture, such as changes in crop and livestock yields, as well as the economic consequences of these potential yield changes

Benefits of Conservation Agriculture

To be widely adopted, all new technology needs to have benefits and advantages that attract a broad group of farmers who understand the differences between what they are doing and what they need. Environmental benefits that protect the soil and make agriculture more sustainable may include a reduction in soil erosion, and thus of road, dam and hydroelectric power plant maintenance costs. More so there is improvement of water quality and air quality coupled with Biodiversity increase and carbon sequestration.

Residues on the soil surface reduce the splash-effect of the raindrops, and once the energy of the raindrops has dissipated the drops proceed to the soil without any harmful effect. This results in higher infiltration and reduced runoff, leading to less erosion. The residues also form a physical barrier that reduces the speed of water and wind over the surface. Reduction of wind speed reduces evaporation of soil moisture.

One aspect of conventional agriculture is its ability to change the landscape. The destruction of the vegetative cover affects the plants, animals and micro-organisms. Some

few profits from the change and turn into pests. However, most organisms are negatively affected and either they disappear completely or their numbers are drastically reduced. With the conservation of soil cover in conservation agriculture a habitat is created for a number of species that feed on pests, which in turn attracts more insects, birds and other animals. The rotation of crops and cover crops restrains the loss of genetic biodiversity, which is favoured with mono-cropping (Vijesh et al, 2023).

Systems, based on high crop residue addition and no tillage, accumulate more carbon in the soil, compared to the loss into the atmosphere resulting from plough-based tillage. During the first years of implementing conservation agriculture the organic matter content of the soil is increased through the decomposition of roots and the contribution of vegetative residues on the surface (Vijesh et al, 2023). This organic material is decomposed slowly, and much of it is incorporated into the soil profile, thus the liberation of carbon to the atmosphere also occurs slowly. In the total balance, carbon is sequestered in the soil, and turns the soil into a net sink of carbon. This could have profound consequences in the fight to reduce greenhouse gas emissions into the atmosphere and thereby help to forestall the calamitous impacts of global warming.

Agronomic benefits

These that improve soil productivity.

Adopting conservation agriculture leads to improvement of soil productivity:

- Organic matter increase.
- In-soil water conservation.
- Improvement of soil structure, and thus rooting zone. (Liben et al 2018; Motera, 2018)
- Conservation agriculture (CA) was evaluated in Ethiopia.
- Short and medium-term effects of CA depends on initial soil properties.
- Improved water infiltration and crop yield can occur in the short-term.

- Yield increase in the short-term is less likely with moderate soil in humid areas.
- Canopy reflectance can be used to study in-season effects of no-till and residue.

The constant addition of crop residues leads to an increase in the organic matter content of the soil. In the beginning this is limited to the top layer of the soil, but with time this will extend to deeper soil layers. Organic matter plays an important role in the soil: fertilizer use efficiency, water holding capacity, soil aggregation, rooting environment and nutrient retention, all depend on organic matter. Conservation agriculture (CA) practices can improve food security, prevent land degradation, and improve the resilience of cropping systems against climate change, irrespective of climatic zones and physiographic differences. Food production on degraded soils without adopting proper management practices does not necessarily decrease food security; instead, it increases environmental problems (Deepak et al., 2020; Joshi et al., 2020).

2.4 Global Spread of Conservation Agriculture

Conservation Agriculture (CA) comprises the practical application of three interlinked principles, namely: no or minimum mechanical soil disturbance, biomass mulch soil cover and crop species diversification, in conjunction with other complementary good agricultural practices of integrated crop and production management. In 2015/16, CA was practised globally on about 180 M ha of cropland, corresponding to about 12.5% of the total global cropland. In 2008/09, the spread of CA was reported to be about 106 M ha. This change constitutes an increase of some 69% globally since 2008/09 (Kassam et al 2018). In 2015/16, CA adoption was reported by 78 countries, an increase in adoption by 42 more countries since 2008/09, respectively. The average annual rate of global expansion of CA cropland area since 2008/2009 has been some 10.5 M ha. The largest extents of adoption are in South and North America, followed by Australia and New Zealand, Asia, Russia and Ukraine, Europe and Africa.

CA systems, comprising minimum mechanical soil disturbance, organic mulch cover, and crop species diversification, in conjunction with other good practices of crop and production

management, are now practiced globally on about 125 M ha in all continents and all agricultural ecologies, including in the various temperate environments. While in 1973/74 CA systems covered only 2.8 M ha worldwide, the area had grown in 1999 to 45 M ha, and by 2003 to 72 M ha. In the last 11 years CA systems have expanded at an average rate of more than 7 M ha per year showing the increased interest of farmers and national governments in this alternate production method. Adoption has been intense in North and South America as well as in Australia and New Zealand, and more recently in Asia and Africa where the awareness and adoption of CA is on the increase.

Conservation Agriculture (CA) has been practised for three decades and has spread widely. We estimate that there are now some 106 million ha of arable and permanent crops grown without tillage in CA systems, corresponding to an annual rate of increase globally since 1990 of 5.3 million ha. Wherever CA has been adopted it appears to have had both agricultural and environmental benefits. Yet CA represents a fundamental change in production system thinking. It has counter-intuitive and often unrecognized elements that promote soil health, productive capacity and ecosystem services. The practice of CA thus requires a deeper understanding of its ecological underpinnings in order to manage its various elements for sustainable intensification, where the aim is to optimize resource use and protect or enhance ecosystem processes in space and time over the long term. For these reasons CA is knowledge-intensive. CA constitutes principles and practices that can make a major contribution to sustainable production intensification. This, the first of two studys, presents the justification for CA as a system capable of building sustainability into agricultural production systems. It discusses some of CA's major achievable benefits, and presents an overview of the uptake of CA worldwide to 2009.

2.4.1 Conservation Agriculture in Africa

Farmers in Africa are successfully adopting Conservation Agriculture as an alternative to the unsustainable conventional farming practices and as a solution to loss of agricultural productivity, soil erosion and land degradation, climate change challenges and ever-increasing food insecurity. Farmers in at least 22 African countries are promoting CA

(Kenya, Uganda, Tanzania, Rwanda, Sudan, Ethiopia , Swaziland , Lesotho, Malawi, Madagascar, Mozambique, South Africa, Namibia, Zambia, Zimbabwe, Ghana, Burkina Faso, Senegal, Cameroon, Morocco, Tunisia and Algeria). CA has also been incorporated into the regional agricultural policies by NEPAD, and it is recognized as a core element of climate-smart agriculture (Kassam et al 2017). Conservation agriculture (CA) is increasingly promoted in Africa as an alternative for coping with the need to increase food production on the basis of more sustainable farming practices. However, success with adopting CA on farms in Africa has been limited, despite more than two decades of research and development investments (Corbeels, 2013).

2.4.2 Conservation Agriculture in Zimbabwe

The government has supported the concept of Pfumvudza/Intwasa – conservation farming – to improve productivity and ensure enough food is available particularly for rural communities. The Government of Zimbabwe set a target to train 1.8 million farmers in Conservation Agriculture (CA) by October 2020 in time for the 2020/21 cropping season. One million farmers have already been trained in the country (FAO 2020). In recent years, there has been a rapid increase in the number of farmers practising CA technologies involving planting basins. The aggressive promotion of the Pfumvudza/Intwasa programme -- a low input sustainable agriculture approach to enhance household food and nutrition security has boosted crop yields and smallholder farmer's resilience (Herald 2021). Zimbabwe adopted the concept in the 2020-2021 farming season as a way of climate proofing agriculture by adopting conservation farming techniques on smallholder farming plots and applying the correct agronomic practices for higher returns. Its massive uptake has improved yields and enhanced household food security for the majority of smallholder farmers, (FAO 2020).

2.5 Impact of Conservation Agriculture on livelihoods

Conservation agriculture (CA) is proposed as a panacea to agricultural problems in smallholder farming systems in the tropics, (Liben et al 2018, Barrera Mosquera, 2018).

According to (FAO 2020), there are three important principles that underpin CA and these are:

- Minimal Soil disturbance
- permanent soil cover
- Crop rotations

Minimum soil disturbance and permanent soil cover help in improving soil organic matter content, reducing water run-off due to increased infiltration, as well as increased soil biological activity (Mango et al 2017). Use of mulch is particularly important for infiltration and reduction in evaporation. This is especially in southern Africa where aridity is predicted to increase the effects of climate change (Kader etal 2019). Crop rotations prevent pests and disease carry-over as well as improving soil fertility when legumes are used (Zohry et al 2018). More so Conservation Agriculture, increases productivity and grain supply to households (Mango et al, 2017). Conservation Agriculture improves food availability at household level.

2.6 Challenges of Conservation Agriculture

Alexander et al (2018), states that Conservation agriculture as an upcoming paradigm for raising crops will require an innovative system perspective to deal with diverse, flexible and context specific needs of technologies and their management. Mazvimavi et al 2010 and Kader et al 2019 concur that failure by smallholder farmers to understanding the system remain a key challenge since C. A systems are much more complex than conventional systems. Furthermore, site specific knowledge has been the main limitation to the spread of CA system, (Barrera 2019). Managing these systems efficiently will be highly demanding in terms of understanding of basic processes and component interactions, which determine the whole system performance. For example, surface maintained crop residues act as mulch and therefore reduce soil water losses through evaporation and maintain a moderate soil temperature (Barrera 2019).

However, at the same time crop residues offer an easily decomposable source of organic matter and could harbour undesirable pest populations or alter the system ecology in some other way (Dechang 2022). No-tillage systems will influence depth of penetration and distribution of the root system which, in turn, will influence water and nutrient uptake and mineral cycling. In addition to the above, there are technological challenges. These challenges relate to development, standardization and adoption of farm machinery for seeding with minimum soil disturbance, developing crop harvesting and management systems, (Amrita et al 2020). Finally, site specificity challenges are also experienced. Adapting strategies for conservation agriculture systems will be highly site specific, yet learning across the sites will be a powerful way in understanding why certain technologies or practices are effective in a set of situations and not effective in another set. (Jatinder et al 2020).

The mind-set of farmers, researchers, extensionists, and policymakers is another notable challenge for Conservation Agriculture. There is a common misperception among farmers, researchers, extensionists, and policymakers that tillage is important for high crop production (Dechang 2022). For CA deep scaling, farmers need guidance and support to change their mindset about CA and understand new concepts and principles and so as to enable an intellectual change in their mindset about CA. Policymakers need convincing explanations and briefs on short vs long-term benefits in order to position their judgment and support to CA development and insertion in agricultural/environmental / social policies.

The other important constraints include lack of knowledge and skills about the CA systems and on how to do it (know-how), shortage of skilled and scientific manpower. (Dechang 2022). The success of the CA system depends on education and training and social mobilization of farmers. Another challenge is the lack of large-scale participatory field demonstrations, field days and farmers' training are other constraints for CA adoption. To encourage adoption of CA requires increasing awareness to farmers with stronger and extensive field demonstrations (Mina et al., 2022, Amrita 2020). There is a lack of community awareness, experience and adoption of the CA technology.

2.7 Conceptual /theoretical framework

Conservation Agriculture (CA) is an approach to managing agro-ecosystems for improved and sustained productivity, increased profits and food security while preserving and enhancing the resource base and the environment, (FAO 2020). CA is characterized by three linked principles , namely: a) Continuous no - or minimal mechanical soil disturbance (i.e., no - tillage and direct sowing or broadcasting of crop seeds, and direct placing of planting material in the soil; minimum soil disturbance from cultivation , harvest operation or farm traffic, in special cases limited strip tillage); b) Permanent organic soil cover, especially by crop residues, crops and cover crops; and 3) Diversification of crop species grown in sequence or associations through rotations or, in case of perennial crops, associations of plants, including a balanced mix of legume and non-legume crops CA principles are universally applicable to all agricultural landscapes and land uses with locally adapted practices. CA enhances biodiversity and natural biological processes above and below the ground surface (Amrita et al, FAO 2020).

CA is an application of modern agricultural technologies to improve production while concurrently protecting and enhancing the land resources on which production depends. Application of CA promotes the concept of optimizing yields and profits while ensuring provision of local and global environmental benefits and services. Zero tillage , along with other soil conservation practices, is the cornerstone of CA (Dumanski et al, 2006).

The (Amrita et al, 2020) definition and the (FAO 2020) definition are consistent with the Zimbabwean Pfumvudza and Umtwasa model where this type of conservation agriculture uses small plots of land sustainably to produce enough food for an average household of six people over the course of a year (Livelihoods and Food Security Programme [LFSP], 2021). The small plots use hoe dug basins implying minimal soil disturbance and precision application of fertilizer on individual plants. Pfumvudza/Intwasa farming's major goal is to help smallholder farmers sustainably guarantee their households' food security.

2.8 Summary of literature review

Conservation Agriculture (CA) has been practised for three decades and has spread widely. Farmers in Africa are successfully adopting Conservation Agriculture as an alternative to the unsustainable conventional farming practices and as a solution to loss of agricultural productivity, soil erosion and land degradation, climate change challenges and ever-increasing food insecurity. Zimbabwe has supported the concept of Pfumvudza/Intwasa – conservation farming – to improve productivity and ensure enough food is available particularly for rural communities. (Mazvimavi et al 2010). While CA is one of the potential remedy to food insecurity its uptake is either low or non-existent. Studies has shown that Conservation Agriculture comes with its own challenges such as mind-set of farmers, researchers, extensionists, and policymakers , poor technology, lack of knowledge and skills and the lack of large - scale participatory field demonstrations , field days and farmers' training (Mina et al, Dchang et al., 2022, Amrita 2020).

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CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

The previous chapter looked at the literature review on the low uptake of Conservation Agriculture practices among smallholder farmers. This chapter deliberates on the research methods, research design, population, sample and sampling procedures used. Research instruments and procedures, data collection and ethical consideration have also been discussed. The chapter ended with a chapter's summary .

3.2 Description of study site

The study was carried out in one District of Zimbabwe. Mudzi District is located in the north east part of the country. The district represents a typically high potential agro – ecological zone IIA. Granitic, nutrient deprived soils are the major soil types in his area (Jérôme, 2007). The area receives about is 1000 mm of rainfall per season (Soropa et al., 2015).

3.3 Research design

A research design is a plan or structure that a study takes to enable a researcher to obtain answers to research questions (Bazeley, 2009). In this study the case study design was used. The researcher justifies the use of the case study method based on the research questions and objectives of the study. A case study method gives a description of real events or situations. As a research design the case study method supports the objectives of the study. According to

Harrison (2017), a case study research through is a may involve a mixed methods approach in which the investigator explores a case over time detailed, in-depth data collection involving multiple sources of information. It allows the researcher to focus on a given and hence manageable unit to undertake an in depth investigation of a phenomenon. For this study, the case study is the uptake of Conservation Agriculture practices among smallholder farmers in Mudzi District. A case study describes an actual situation involving a desiccation be made or problem to be solved.

Case studies involve a great deal of investigating issues and thus is laborious and time consuming. In this respect when one goes native, he or she likely to become part of group hence subjective reporting influenced the outcome of the research. The report may fail to achieve the intended goals. To overcome these limitations, the researcher was a key instrument of research in line with the recommendations by Nyaranda (2014). This gives the researcher the opportunity to use direct experimental knowledge.

3.4 Sampling procedure

A sample is a representative segment of a larger population (Bryman, 2012). In quantitative research, the sample size and how it is selected can be used to establish the reliability of the results of the study.

3.4.1 Sample Size

Different samples were used for each objective. For objectives 1 and objective 2 the following was done;

Objective 1 and 2

A multi stage sampling technique was used for sampling starting with purposeful selection of three Agro Economic Zone followed by purposeful selection of one district in each Agro Economic Zone. The third stage involved random selection of three wards in Mudzi District. The fourth stage was random selection of a total of 40 farmers in each ward (25 adopters and 15 non-adopters of CA) from a list of farmers provided by Agriculture

Research and Extension Services (AGRITEX). A pretested semi-structured questionnaire was then administered by trained enumerators.

Objective 3

A total of 360 smallholder farmers participated in the survey between March 2023 and April 2023. Out of the 360 participants who took part in the survey questionnaire, only 349 (97 %) fully completed the questionnaire and these were included in the final analysis. The sample include smal scal farmers and Agricultural Extension workers. These were selected because of them implementing the CA practices.

3.4.2 Sampling Techniques

Sampling techniques are the ways in which an appropriate sample size is selected for the wider study (Bryman, 2012). There are a number of accepted techniques that can be used. Chiromo (2009) posits that purposive sampling involves choosing the samples to be used based on the researcher`s knowledge of the population and the purpose of the study. Kumar (2017) views purposive sampling as the judgment of the researcher as to who can provide the best information to achieve the objectives of the study. The researcher used purposive sampling technique to select AGRITEX Extension workers because it allowed the researcher to have data rich participants. Additionally, simple random sampling technique was also utilised in selecting small scale farmers in Mudzi District.

3.5 Data collection procedures

Having obtained a letter of introduction from BUSE, the researcher sought for permission from relevant authorities to conduct the study. The researcher went on to draft questions for the questionnaire and the interviews guide in connection with the research questions. Random sampling and purposive sampling were used to recruit respondents. The researcher made use of the questionnaire and interviews in the data gathering process. The researcher self- administered questionnaires and hand delivered them and collected after three days when they were completed. The three days gave informants ample time to respond, thus allowing them to respond on their own time. No identification was required on the

questionnaire therefore they freely answered the questions.

Five key participants participated in the study. Participants were provided with an interview schedule that indicated when they would be interviewed (date, time and venue). Thereafter, the interviews were set up by contacting the participants in advance and establishing an appointment for the interviews. Participants were reminded of the date and time through physical visits a day before the interview date. The interviews were conducted at the participants' place of work during their free time convenient to them, which was either at lunch hour or after hours. To build relations and trust, the researcher conducted face to face interviews with participants and each session took about 20 - 25 minutes. The interviews were helpful because they enabled the researcher to identify non-verbal cues that were used to probe for more information. The researcher recorded the interviews following the order in which they were undertaken instantaneously after the session and while the memory was fresh on what had emerged. During the transcribing process the researcher kept on highlighting with different colours some of the notes answering the study questions. The interviews guide will be included in the appendix section.

3.6 Data analysis and Presentation

The following are the measures that the researcher used to analyse both the qualitative and the quantitative data for the study.

Qualitative Data Analysis: data was analysed with the use of thematic and content analysis. After conducting interviews which were recorded on the phone, some of which were noted down. The researcher came up with themes from the findings that were generated. Upon deriving the themes from the findings of the study, the researcher further analysed the content in each and every theme.

Quantitative Data Analysis: data obtained with the use of the questionnaire research instrument was analysed with the use the Statistical Package for Social Sciences (SPSS). Upon completion of the data collection process, the researcher cleaned and sorted the data. The questionnaires that were not fully filled were excluded from analysis. Data was then

coded and put into the SPSS software where is was analysed with use of various analytical methods. Some of these include descriptive analysis relating to mean, standard deviations and frequency. Inferential analysis was also carried out in which the correlations and regression analysis were carried out to determine the relationship between variables. Data was presented with the use of tables and figures.

3.7 Ethical considerations

Ethics refers to well based standards of right and wrong that prescribe what humans ought to do, usually in terms of rights, obligations, benefits to society, fairness, or specific virtues (Velasquez, Andre, Shanks, & Meyer, 2008). Magwa and Magwa (2015) define ethics as rules of conduct of researchers carrying out research. Participants were encouraged to use pseudonyms and no real names were used. The respondents were treated equally and fairly in the selection as well as during the course of the study as enshrined in the principle of justice. Respondents were treated with respect and politeness through-out the research process. Their right to privacy and confidentiality was observed through anonymity procedures that safeguard the information provided by the respondents.

3.8 Summary

This chapter explained the research methodology used to undertake this study. A Case study research deign was described in this chapter and the mixed research methodology was described as well. The sampling technique used was purposive sampling because it gives the researcher convenience in terms of costs and time. The researcher gave an explanation on data collection plan and data analysis procedure. Chapter four focuses on data presentation, data analysis and for the first two objectives of the study.

CHAPTER 4: Behaviour of smallholder farmers towards adoption of Conservation Agriculture in Zimbabwe

Abstract

Much of the research on conservation agriculture adoption has focused on its benefits while little attention has been paid to the behaviour of smallholder farmers towards the technology. Therefore, the objective of this study was to investigate the behaviour of smallholder farmers towards the adoption of conservation agriculture in Mudzi District, Zimbabwe. Data was collected through a household questionnaire, triangulated through focus group discussions, key informant interviews and personal observations. Data was analysed using percentages, means and inferential statistics. The results indicate that majority (> 80 %) of the smallholder farmers depends on agriculture for their income and food security although less than 10 % of the respondents had received any formal agricultural training. On the other hand, despite more than a decade of promotion of conservation agriculture in the district, less than 10 % of the farmers had more than 10 years of experience in the technology. On the other hand, the respondents had high knowledge about the social, economic and environmental benefits of conservation agriculture. The level of knowledge of the farmers towards conservation agriculture was explained by: age, gender, education, visit to demonstration centres and years of practicing the technology. The results also indicate that majority of the non-adopters had an indifferent perception towards conservation agriculture. The significant ($P < 0.05$) variables in explaining the perception of the farmers towards conservation agriculture were: age, gender, education, visit to demo sites, experience in CA and agriculture. There was a weak but significant correlation between knowledge and perception ($Rs = 0.306$, $P < 0.05$) and knowledge and adoption ($Rs = 0.484$, $P < 0.05$) but a strong and significant correlation between perception and adoption ($Rs = 0.808$, $P < 0.05$). This research confirms that farmers, intention to adopt conservation agriculture seems to be constrained by the low level of perception. Therefore closing the perception gap could help improve adoption of conservation agriculture in Zimbabwe.

Keywords: *Food security, knowledge, perception, Zimbabwe*

4.1 Introduction

The adoption of sustainable land management is urgent and critical to addressing sub-Sahara Africa's (SSA) food security and nutritional objectives; arrest rampant land degradation (Pereira, 2017) and for climate resilience. Based on simultaneous application of three principles (Baudron et al., 2015): minimum soil disturbance, crop rotations and diversification, maintenance of permanent soil cover (Kassam et al., 2009; Richards et al., 2014), Conservation Agriculture (CA) is one of the several land management practices with massive potential to reverse land degradation (Lal, 2015). Maintaining a permanent cover protects the surface of soil from direct raindrop impact (Busari et al., 2015), improves the organic matter content, water infiltration and storage capacity of the soil (Hobbs et al., 2008).

Crop rotation and diversification improves dietary diversity (Pellegrini & Tasciotti, 2014), pests and disease control, biodiversity (Giller et al., 2015) and nutrient cycling (Kassam et al., 2014). The practice can also improve adaptation to climate change (Jost et al., 2016). Reduced tillage decreases the environmental footprint of agriculture; tillage costs; loss of soil organic matter while improving timeliness of crop establishment (Hobbs et al., 2008). Farmers have been practising different types of the components of CA features well before the term was invented (Giller et al., 2015).

In southern Africa and particularly in Zimbabwe, CA been promoted to combat decline in soil fertility, restore degraded land and stabilize yields in smallholder farming systems

(Mazvimavi et al., 2010.) There are numerous benefits associated with CA. It promotes sustainable agricultural production without increasing the carbon footprint of agriculture and assists farmers to cope with the risks posed by climate change (Beuchelt & Badstue, 2013); it can enhance soil fertility (Naab et al ., 2017) reduces soil erosion (Giller et al., 2009); contributes to climate change mitigation (Liu et al., 2016). The long term benefits of CA include: increasing agricultural yields and food security; reducing costs of production (Nyanga, 2012; Pittelkow et al., 2015; Makate et al., 2017); reducing drudgery when planting is mechanized and herbicides are used for controlling weeds (Johansen et al., 2012; Giller et al., 2015).

Despite more than fifty years of research and extension, adoption of CA is limited and piecemeal in southern Africa (Brown et al., 2017). Specifically, less than 1 % of the total arable area is under CA (Hove et al., 2011) although the percentage is about 8 .3 % in Zimbabwe (Richards et al., 2014). Reasons for limited adoption of CA are reported in a number of studies. Rusinamhodzi (2015) reported an increase in labour burden for manual weeding in the absence of herbicides in Murehwa, Zimbabwe. This is also supported by earlier findings by Marongwe et al. (2011) who indicated that smallholder farmers in Zimbabwe have raised concern over the increased labour demand for the preparation of basins and weeding under CA. Grabowski & Kerr (2014) reported an increase in labour burden where CA was practiced without herbicide in Mozambique.

Kiptot et al. (2007) reported massive investments in labour and the lag time between adoption and accrual of benefits as constraints to adoption of CA among smallholder farming systems in western Kenya. Another challenge that has been documented by several authors is the issue of competition for crop residues for mulching or feeding livestock in many smallholder farming systems globally (Powlson et al., 2016), Africa in general (Brown et al., 2018b) and Zambia and Zimbabwe in particular (Mupangwa & Thierfelder, 2014) Other studies have reported lack of equipment and inputs as some of the barriers of CA adoption in SSA (Johansen et al., 2012; Sims et al., 2012) while other cite lack of information on input sources (Nyanga, 2012); dearth of extension services (Brown et al.,

2018a; Yahaya et al., 2018; lack of credit (Yahaya et al., 2018), non-functional markets (Thierfelder et al., 2015b) and difficulties in changing the mindset of famers (Bunderson et al., 2011) as additional constraints to adoption of CA in the region. The prescriptive nature of marketing CA (Brown et al., 2018b) instead of providing farmers with a basket of technologies that match their circumstances has stifled adoption (Giller et al., 2015). Using the metaphor of "when you are a hammer everything is a nail" CA should not be taken as a panacea to all agricultural production constraints.

There are relatively few scientific publications exploring the characteristics of smallholder farmers that influence their behaviour towards adoption of CA in SSA to date, especially in Zimbabwe. This is despite voluminous literature on the influence of consumer behaviour towards adoption of innovations (Nimako et al., 2016). This study uniquely addresses this gap by employing eleven statements for judging the knowledge of the respondents on the social, economic and environmental viability of CA and three statements for judging the perceptions of the non – adopters in light of documented limited adoption of CA entrenched socio-economic limitations in Zimbabwe, (Mazvimavi & Twomlow, 2009; Pedzisa et al., 2015a Kunzekweguta, 2016).

Information is important for the adoption of new agricultural technologies (Jabbar et al., 2003). In Japan, Palacios (2005) indicated that the attitude of farmers towards CA was influenced by socio - demographic variables. From a study in Iran, Sadati et al. (2010) revealed that knowledge was a significant variable in explaining attitudes towards sustainable agriculture. Hasan et al. (2017) emphasized the role of knowledge in adoption of agricultural innovations. On the other hand, one's attitude has implications for behaviour (Bergevoet et al., 2004). The perception guides behaviour (Grossman, 1972). Smallholder farmers require adequate knowledge and positive perceptions towards sustainable agriculture. Farmers with negative perceptions about sustainable agricultural practices are highly unlikely to adopt these practices (Hall et al., 2009).

4.2 Material and Methods

4.2.1 Description of study area

The study was carried out in one District of Zimbabwe. Mudzi District is located in the north east part of the country. The district represents a typically high potential agro – ecological zone IIA. Granitic, nutrient deprived soils are the major soil types in his area (Jérôme, 2007). The area receives about is 1000 mm of rainfall per season (Soropa et al., 2015).

4.2.2 Research Design

Data was collected on the socio – economic attributes of the respondents and their knowledge and perceptions (K&Ps) on CA. However, the perception attribute was only assessed on non-adopters to evaluate their reasons for not adopting CA given that the behaviour by neighbours is important in technology adoption (Brown et al., 2018b). K&Ps were measured using a 3 - point Likert scale . Although initially we used a 5 - point Likert scale, we later adopted a 3 - point Likert scale based on pre -testing experience. The assigned scores were 3, 2 and 1(Agree, Neither Agree or Disagree and Disagree, respectively).

4.2.3 Sampling procedure

A multi stage sampling technique was used for sampling starting with purposeful selection of three Agro Economic Zone followed by purposeful selection of one district in each Agro Economic Zone. The third stage involved random selection of three wards in Mudzi District. The fourth stage was random selection of a total of 40 farmers in each ward (25 adopters and 15 non-adopters of CA) from a list of farmers provided by Agriculture Research and Extension Services (AGRITEX). A pretested semi-structured questionnaire was then administered by trained enumerators.

The questionnaire was triangulated with focus group discussions (FGDs) (three FGDs per district - each focus group comprised of 12 participants, chosen based on age group, gender and social class), Key informant interviews were also conducted with participants from AGRITEX, Department of Irrigation , Rural District Council , Care International, World Vision, Plan International, ward councillors, village heads, Grain Marketing Board and church leaders. These methods were augmented by personal observations.

4.2.4 Data collection procedure

The knowledge (perception) score was obtained from responses given by farmers to knowledge (perception) questions after analysis of the data using Statistical Package for Social Scientists (SPSS) version 16.0. The researcher also performed a pair- wise correlation analysis in order to establish the relationship between knowledge and perception, knowledge and adoption and perception and adoption.

4.2.5 Data analysis procedure

Objectives 1 and 2 were analysed using percentages, means, a 3 point Likert decision rule model and multinomial regression, objective 1 was analysed using percentages and frequencies. According to the Likert Model decision rule by Williams (2015), $\geq$ 2.0 is accepted while < 2.0 is rejected.

4.2.6 Challenges encountered during data collect

The major challenge encountered during data collection are presented below;

- Sample size generalizability
- Getting consent and approvals from relevant departments
- Busy schedules of participants
- Bureaucracy

4.3 Results

4.3.1 Socio-demographic data

The majority (53 %) of those completing the questionnaire were women, with approximately the same proportion being over 50 years old. Almost three quarters of respondents were married and majority had only primary education. Less than 10 % of farmers had received any formal training in agriculture but over 80 % relied on the farm for their income. Less than 10 % had more than 10 years' experience of CA (Table 4.1).

Table 4.1 : Selected demographic attributes of respondents

SOCIO-ECONOMIC ATTRIBUTES	FREQUENCY	%

SEX		
Males	164	47
Females	185	53
AGE (Years)		
< 21	1	0.3
21 - 30	21	6
41 – 50	67	19. 2
> 50	111	31.8
MARITAL STATUS		
Married	251	71. 9
Single	98	28.1
EDUCATION LEVEL		
No formal education	192	55
Primary	70	20
Secondary	59	17
Tertiary	28	8
MAJOR SOURCE OF INCOME		
Agriculture	292	83.7
Remittances	44	12.6
Off - farm equipment	13	3.7
EXPERIENCE IN PRACTICING CA		
0	120	34.4
< 5	108	30. 9
5 - 10	94	26.9
> 10	27	7.7

4.3.2 Respondents' knowledge on CA

4.3.2.1 Classification of respondents based on CA knowledge

In addition to assessing the level of knowledge of the respondents on CA, the study also assessed the socio-economic determinants of the knowledge variable using a multinomial regression model. The log likelihood Ratio Chi^2 was 284.125 and the log likelihood was -158. 6825 meaning that the model gave a very good fit to the data. The significant socio-economic variables on knowledge on CA were age, gender, level of formal education, visits to demonstration centres and experience with CA (Table 4.2). Table 4.3 shows that 62 .5 % of the respondents had high CA knowledge levels.

Table 4.2: Classification of farmers on knowledge level of CA

Knowledge	Frequency	%	Mean	SE

category				
High	218	62. 5	2 .46	0 .043
Medium	88	25. 2		
Low	43	12. 3		

4.3.2.2 Classification of respondents based on CA knowledge

Table 4.3: Knowledge level on CA multinomial regression model

Variable	Chi - square	P - value
Age	16 . 02	0 .014 *
Gender	10.335	0.012*
Marital Status	12.385	0.135
Education level	35.416	< 0.0001
Formal Agricultural Training	0.303	0.859
Master Farmer Training	5.946	0.051
Experience in agriculture	8.387	0.211
Belonging to a social group	0.705	0.703
Visit to Demo sites	6.968	0.023
Attendance at conferences	3.42	0.843
Years of practicing CA	132.604	< 0.0001*

Likelihood Ratio Chi^2 284.125; Pseudo R^2 0.453 Log Likelihood - 158.6825;

Note: * significant at 5 % probability level

4.3.3 Farmers' perception towards CA

4.3.3.1 Classification of respondents' based on perception towards CA

The questionnaire sought to assess the respondents' perception towards CA using perception statements. The mean value of the perception variable range from 2.10 to 2.12, reflecting a high degree of agreement from the respondents to the variable. The respondents agreed with all the statements in the construct. The standard error values, which range from 0.030 to 0.031 indicate a fair range of the responses (Table 4.4).

According to the results, the perception of 46 non-adopters towards CA was shaped by lack of CA equipment (mean score of 2.12; standard error, 0.57), decline in yields under CA

(mean score of 2.10; standard error, 0.57) and unmanageable problems (mean score of 2.10; standard error, 0.56). This is further supported by Table 4.5 which shows that majority of the non-adopters had indifferent perceptions towards CA.

Table 4.4: Perception, model reliability and mean score of non-adopters about CA

Knowledge category	Frequency	%	Mean	SE
High	41	1.7	1.55	0.70
Medium	232	66.5		
Low	76	21.8		

In addition to assessing the perception of the respondents towards CA, the researcher also assessed the socio-economic determinants of the perception construct using a multinomial regression model . The model for Mudzi district.

4.3.3.2 Determinants of respondents' perception on CA

The log likelihood Ratio Chi^2 was 289.602 and the log likelihood was -140.584 (Table 4.5) implying that the model gave a very good fit to the data. Perception of the respondents towards CA was explained by age, gender level of formal education, visit to demo sites, attendance to conferences and experience in agriculture and CA (Table 4.5).

Table 4.5: Perception on CA multinomial regression model

Variable	Chi - square	P - value
Age	16.199	0.04*
Gender	0.336	0.038*
Marital Status	9.708	0.280
Education level	12.851	0.017*
Formal Agricultural Training	4.191	0.123
Master Farmer Training	4.016	0.134
Experience in agriculture	9.679	< 0.0001
Belonging to a social group	0.455	0.797
Visit to Demo sites	5.528	0.003*
Attendance at conferences	6.252	0.004*
Years of practicing CA	3.34	0.032*

Likelihood Ratio Chi^2 289.602

Pseudo R2 0.485

Log Likelihood - 140.584

Note: * significant at 5 % probability level

4.3.4 Correlation between knowledge and perception; knowledge and adoption and perception and adoption

There was a weak but significant correlation between knowledge and perception (R_s = 0.306, $P < 0.05$); knowledge and adoption (R_s = 0.484, $P < 0.05$) but a very strong and significant correlation between perception and adoption (R_s = 0.808, $P < 0.05$).

4.4 Discussion

4.4.1 Demographic data

In general, the study found that majority of the respondent were female. Previous studies have shown that majority of farmers in Zimbabwe are women (FAO, 2017). CA being a knowledge intensive agricultural practice (Cheesman et al., 2017) requires adequate extension. However, some studies have indicated that women farmers in Zimbabwe have challenges in accessing extension (Mango et al., 2017). Studies in Zambia and Zimbabwe have revealed that extension agents tends to pay more visits to male farmers (Ng'ombe et al., 2017). The results also indicate that majority of the respondents were greater above the age of 50 years.

Past studies have indicated that age increased chances of adoption of improved agricultural technologies. However, this is just an assumption (Mwangi & Kariuki, 2015). In a study in Ireland, Howley et al., (2012) found negative association between age and technology adoption, where elderly farmers were less likely to adopt improved agricultural technologies. This is not surprising given that younger farmers, who maybe more educated may easily evaluate the benefits of new technologies, while elderly farmers might be too conservative.

To the contrary, older farmers might have gained more experience through experiential learning making them better able to evaluate the benefits of new technologies (Kariyasa & Dewi, 2011). The results also indicate that majority of the households depend on agriculture for their livelihoods. Past studies have shown that agriculture is the major source of income for majority of the rural population in Zimbabwe. The demographic data was aggregated

and not analysed at district level since the main point was to give a helicopter's view of the respondents, given that our main focus was to give an in-depth understanding of the application of non socio economic attributes to determine barriers to CA adoption.

4.4.2 The respondents' perceptions towards CA

Results indicate that the perception of non-adopters towards CA was low. The low perception was attributed to lack of CA equipment, decline in crop yields and unmanageable challenges under CA. These items are discussed in detail below.

4.4.2.1 Social viability of CA.

Performance improves over time

The respondents indicated that the performance of CA improves over time with a mean score of 2.42 (standard error = 0.045) as shown in Table 4.2. Several studies (Rusinamhodzi et al., 2011; Brouder & Gomez-Macpherson, 2014; Corbeels et al., 2014; Thierfelder et al., 2017) have reported that the benefits of CA improve over time. This is supported by Thierfelder et al. (2017) who indicated that the benefits of CA take between 3 - 5 years to accrue. Thierfelder et al. (2012) only observed significant yield differences between CA and non-CA plots after five seasons on farm trials in Madziwa, Zimbabwe, while Thierfelder & Wall (2012) observed that CA did not result in immediate increase in yields of maize in contrasting agro-ecological regions of Zimbabwe. There are several reasons that delay the benefits of CA.

When moving from conventional systems to CA, farmers have to learn new agronomic and land management strategies which may delay the performance of CA systems (Thierfelder et al., 2017). Additionally, changing to no tillage system, with residue retention, may result in increase in weed intensity and dynamic (Mashingaidze et al., 2012; Sharma & Singh, 2014), potential outbreak of some pests and diseases in the short term as the mulching

material may have disease carryover effect (Giller et al., 2015). Farmers need new knowledge to address these issues (Tekle, 2016) and lack of adequate knowledge has been cited as one of the major challenges to early adoption of CA in Brazil (Evers & Agostini, 2001).

Result in observable yield increments

The respondents indicated that they observed increase in crop yields after adoption of CA with a mean score of 2.39 (standard error = 0.043) as indicated in Table 4.2. Previous studies have also noted a significant increase in crop yields after the adoption of CA. For example, Mazvimavi et al. (2010) found that yields under CA were much higher than conventional plots in Zimbabwe. Several other studies also attest to the yield benefits of CA compared to conventional plots particularly under low rainfall conditions (Mazvimavi, 2016).

A meta-analysis by Rusinamhodzi et al .(2011) found out that maize yield was higher under CA in low rainfall areas. Similarly, Nyamangara et al . (2014) observed yield benefits of CA in the drier parts of Zimbabwe. However, Ndlovu et al. (2014) observed that despite a doubling net increment on maize yields, farmers in drier areas of Zimbabwe did not realise the full benefits of using CA due to moisture stress. Although Baudron et al. (2012) observed contrasting results on cotton yields in Zimbabwe, which can be explained by the physiology of cotton (Mazvimavi, 2016).

In Zambia, Ngoma et al. (2015) observed that CA was more effective in increasing yields in drier areas compared to wetter regions . Nyagumbo et al. (2016) found out that CA was superior in stabilising crop yields in drier conditions in Malawi and Mozambique. The increase in yields under CA has also been corroborated by experiences of farmers in Ethiopia, Kenya, Uganda, Malawi, Zambia and Mozambique (Brown et al., 2018b). While Farooq et al. (2011) found that yields of various crops were consistently higher in CA systems compared to non-CA plots in USA, Australia and Europe where rainfall was the

most limiting factor. The mechanisms behind increased yields in CA systems under drier conditions include, increased water infiltration and soil moisture storage (Thierfelder et al., 2017).

Easy to practice

The respondents indicated that CA was easy to practice with a mean score of 2.17 (standard error = 0.049) as shown in Table 4.2. This came as a surprise given the numerous challenges that have been reported in implementation of CA in the smallholder farming sector.

Previous studies have indicated that farmers in semi-arid areas of Zimbabwe have expressed concern over the need for increased weed frequency under CA particularly during the initial years of adoption (Wagstaff & Harty, 2010). They also have difficulties in raising adequate crop residues considering that in southern Africa and Zimbabwe in particular, there is increased competition for crop residues after the harvesting period when there is unrestricted livestock access to the residue in the field (Mupangwa et al., 2012; Mupangwa & Thierfelder, 2014).

Additionally, there is limited biomass production in most African smallholder farming systems (Brown et al., 2018b). The other inherent challenge is that most smallholder farmers in Africa find it difficult to grow crops without tilling the land (Bunderson et al., 2011). Some authors have highlighted the lack of appropriate equipment (Johansen et al., 2012) and functional markets (Thierfelder et al., 2015b) as some of the barriers of practicing CA.

4.4.2.2 Environmental viability of CA

Reduces soil erosion

The respondents indicated that CA was important in controlling soil erosion with a mean score of 2.64 (standard error = 0.037) as indicated in Table 4.2. Previous studies have credited CA for controlling soil erosion (Giller et al., 2009; Dillaha et al., 2010; Thierfelder et al., 2012; de Freitas & Landers , 2014). In Zimbabwe, CA was first introduced in the form

of conservation agriculture in the 1990s (Oldrieve, 1993) following excessive land degradation caused by the introduction of the plough (Nyamadzawo et al., 2013).

In the USA, CA was introduced in the form of reduced tillage in response to severe soil erosion following the USA "dust bowls" of the 1930s. (Kassam et al., 2014a) Similarly in southern part of Brazil, the introduction of CA in the form of reduced tillage was in response to soil erosion problems (Bolliger et al., 2006).

CA can restore degraded lands

The respondents credit CA for restoration of degraded lands with a mean score of 2.46 (standard error = 0.042) as shown in Table 4.2. This is in consistent with Lal (2014), who indicated that CA is one of the sustainable land management practices that can reverse land degradation. Rotation with legumes and leaving crop residues on the surface may stimulate biological activity which is important in the restoration of degraded lands (Nezomba et al., 2015). Mafongoya et al. (2016) also emphasized the importance of CA to reverse land degradation in Zimbabwe. (Chiputwa et al., 2011) found that smallholder farmers in the northern part of Zimbabwe had high levels of awareness on CA to reduce soil erosion and reverse land degradation. Therefore CA can reverse land degradation especially soil nutrient mining, the dominant type of soil degradation in SSA (Henao & Baanante, 2006). This is in line with the original rationale for development of no - till strategies in the USA (Kassam et al., 2014a), which was also valid for Africa (Giller et al., 2015) and Zimbabwe (Nyamadzawo et al., 2013).

Environmentally friendly

The respondents in the study area have a high level of knowledge on the benefits of CA to the environment with a mean score of 2 .60 (standard error = 0 .037) as shown in Table 4.2. They indicated that CA improves the quality of the environment. Numerous studies in Zimbabwe have demonstrated the ability of CA to control soil erosion (Baudron et al., 2015). On the other hand, the increased biological diversity reduces application of

herbicides, chemical fertilizers and pesticides , which enhances quality of water (Eslami, 2014). Many of the environmental benefits of CA, which may come at a cost to the farmer are however enjoyed by the wider society (Kassam et al., 2014b). This calls for an in depth cost - benefits analysis so that farmers practicing CA may receiving monetary incentives for environmental benefits of CA which are enjoyed by the wider community.

Controls pests and diseases

The study revealed that CA controls pests and diseases with a mean score of 2.43 (standard error = 0.043) as indicated in Table 4.2. Crop rotation and diversification is one of the key principles of CA. Where legumes are used, they act as break crops since legumes are not vulnerable to the same pests and diseases which attack cereals (Zander et al., 2016). Additionally, the increased biological diversity under CA implies a greater biotic diversity of potential pest predators (Kassam et al., 2009). In support of this, (Hobbs et al., 2008) reported an increase in predatory beetles, spiders, ants, wasps and earwigs under CA in south Asia due to increase in ground cover.

In contrast to the above, (Baudeon et al., 2007) found out that farmers in southern province of Zambia believed that crop residues can harbour pests and diseases. Thierfelder et al. (2015a) also observed an increase in pests and diseases outbreak in the initial phase of CA adoption in some parts of southern Africa. The above discussion implies that judicious application of agrochemicals and integrated pests management are prerequisites for the control of pests and diseases under CA practices.

4.4.2.3 Economic viability of CA

Reduces costs of labour

Farmers indicated that CA reduces labour costs with a mean score of 2.29 (standard error = 0.048) as indicated in Table 4.2. Labour intensity leads to partial adoption of CA

(Chiputwa et al., 2011) which supports earlier studies that some farmers fail to adopt CA due to labour limitations (Haggblade & Tembo, 2003; Baudeon et al., 2007). Some studies have however reported an increase in labour costs in the preparation of planting basins under the basin typology of CA (Mazvimavi et al., 2010). The labour requirement under this system will however decline especially under heavy textured soils where the basins can be maintained during winter (Mazvimavi & Twomlow, 2009).

Labour requirements in basin maintenance can be a major impediment to adoption of CA by most smallholder farmers in Zimbabwe considering that most soils are granitic derived sand soils. Elsewhere, farmers in Brazil have reported significant reduction in labour costs due to adoption of CA (Evers & Agostini, 2001). Labour availability plays a key role in the likelihood of farmers adopting CA (Thierfelder et al., 2015b) especially in most African set ups where there is limited labour due to rural urban migration and the HIV/AIDS pandemic.

Reduces costs of inputs

The respondents indicated that CA reduces costs of input with a mean score of 2.51 (standard error = 0.039) as shown in Table 4.2. Although adequate nutrient supply is essential for sustainable agricultural productivity, previous studies have indicated that CA systems require less inputs compared to conventional systems (Giller et al., 2015). This is also consistent with the fact that in most parts of southern Africa including Zimbabwe, the term CA is synonymous with conservation farming (Mazvimavi & Twomlow, 2009) where farmers practice the basin typology of conservation farming and seeds and fertilizers are concentrated in these basins every season. Friedrich & Kassam (2011) noted that the yield benefits of CA are obtained with less inputs compared to conventional agriculture.

In support of Friedrich & Kassam (2011), Corbeels et al., 2014; Steward et al., 2018) observed that CA plots outperformed non-CA plots even if the former had lower supplies of nutrients. Elsewhere, CA has resulted in reduced tractor use, culminating in huge savings in fuel costs in Brazil (Tekle, 2016). On the other hand, CA has proven to increase yields by promoting biological processes and agronomic practices that enhance soil fertility, pests

and weed control (Tekle, 2016). Additionally, legume based rotations enhance soil nitrogen status in cropping systems (Mafongoya et al., 2016) which can reduce nitrogen applications.

However, the legumes do not have ready markets in most African farming systems (Brown et al., 2018b). To address this challenge, there is need to explore the use of multi-tasking non - legume cover crops such as radish which is known to scavenge nitrogen from deeper layers, for use by the subsequent crop in rotation thereby decreasing input costs. The radish roots can also penetrate compacted layers under no till operations, thereby creating a fine tilth for growth of subsequent crops. Radish may also supress weed germination (American Society of Agronomy , 2009). Thierfelder et al. (2018) also suggested the integration of leguminous trees such Gliricidia which doubles up as a cattle feed and source of nitrogen. However, in the medium term farmers may increase cost of production due to the need to buy herbicides and related CA equipment (Mazvimavi, 2016).

*Improves yield*s

The respondents indicated that CA leads to improved yields with a mean score of 2.58 (standard error = 0 .041) as shown in Table 4.2. However, a review of several studies suggest that no till on its own tend to decrease yields (Pittelkow et al., 2015). It is however important to point out that the yield penalty of no till is minimised where no till is combined with mulching and crop rotation (Pittelkow et al., 2015). The yield increments attributed to improved physical , biological and chemical properties of soils are realised in the long run under CA. However, short term yield improvements under CA are mainly due to early planting, (Giller et al., 2015).

Improves income

The respondents indicated that CA systems increase overall farm income with a mean score of 2.54 (standard error = 0 .041) as indicated in Table 4.2. Majority of studies have indicated that CA reduces machinery costs (Kassam et al., 2009) consequently leading to reduced costs of fuel, repair and maintenance of machinery. There are also some cost savings related to decline in pests and diseases outbreaks due to increase in natural

predatory insects and breaks in pests life cycle under CA (Evers & Agostini , 2001). All these together with the yield benefits of CA lead to increase in farm income over time. Although farmers indicated that CA results in the increase in labour burden for weeding in consistent with Mazvimavi et al. (2010), net savings in labour costs are possible in the long run (Giller et al., 2009).

4.4.3 Factors determining respondents' knowledge on Conservation Agriculture

4.4.3.1 Age

The results demonstrate that the age of the household head was statistically significant in influencing the level of knowledge about CA. Previous studies have indicated that the age variable can produce mixed results on technology adoption. This is corroborated by Akudugu et al. (2012) in their study on technology adoption in Ghana. Maumbe & Swinton (2000) however found that age is a significant factor in the adoption of integrated pest management practices in Zimbabwe . Also Simtowe et al. (2011) found out that older farmers in Tanzania had higher propensity of seeking new technologies. Additionally, Pedzisa (2016) found out that knowledge is an important variable in CA adoption in Zimbabwe.

4.4.3.2 Gender

Study findings show that the gender of the respondent has a significant influence on knowledge about CA. The available literature shows that women in SSA have inadequate knowledge of where they can get farming inputs (Nyanga, 2012). This may be due to limited access to extension services as Makate et al.(2017) reported that women in the region have limited contact with extension providers. Female farmers face exposure challenges because of (a) lack of funds (b) insecurity (c) household responsibilities (Jost et al., 2016). Cultural beliefs also prohibit women from participation in most public gatherings (Beuchelt & Badstue , 2013). In order to improve access to extension by women,

government need to provide adequate transport services to extension personnel to improve extension delivery.

4.4.3.3 Education

Education has a significant influence on knowledge about CA. Education is a major measurement of human capital and this explains the significant correlation between education and CA knowledge (Uematsu & Mishra, 2010). Maumbe & Swinton (2000) found out that education is significant variable in adoption of integrated pest management practices in Zimbabwe. However, the variable can produce mixed results especially where agriculture is not the major source of income for the educated farmers (Uematsu & Mishra, 2010).

4.4.3.4 Attendance to demonstration sites

Study results show that attendance to demonstration sites variable has a significant effect on CA knowledge level. This can be attributed to the effectiveness of learning by doing and observations and the ability of demos to reduce risk propensity in Zimbabwe (World Vision U.S, 2017). Experience in CA also had a significant influence on level of knowledge about CA since experience is the best form of learning for the elderly. Farmers with more experience with CA can leverage on the wealth of knowledge gathered through experimentation (Kunzekweguta, 2016).

4.4.4 The respondents' perceptions towards CA

Results indicate that the perception of non-adopters towards CA was low. The low perception was attributed to lack of CA equipment, decline in crop yields and unmanageable challenges under CA. These items are discussed in detail below.

4.4.4.1 Lack of equipment

The non-adopters indicated that lack of equipment was a significant factor in explaining the indifference in perception of non-adopters towards CA. Majority of farmers in Zimbabwe practice basin typology of CA (Pedzisa et al., 2015b). Farmers who practice CA in Mudzi district have to prepare the basins every season since the granitic derived sand

soils are dominant soil types in Mudzi district. In such soils basins cannot be maintained during winter (Mazvimavi & Twomlow, 2009).

Although the proponents of CA call it "dhiga udye" (dig and eat) in Zimbabwe, some have coined "*dhiga ufe*" (dig and die), because of labour requirements in the preparation of basins (Andersson et al., 2011). During the focus group discussion , it was indicated that some adopters had joined CA cooperatives that help them with basin preparation.

4.4.4.2 Decline in crop yields

The respondents indicated that the possibility of decline in crop yields under CA was a significant factor in explaining the low perception of non-adopters towards CA. Several studies have indicated that smallholder farmers in Zimbabwe do not apply all the principles of CA together. The yield penalties that arise when farmers do not simultaneously apply all the principles of CA at the same time are discussed elsewhere in this study.

4.4.4.3 CA may lead to serious problems

The respondents indicated that possibility of getting into serious problems was a significant factor in shaping the perception of adopters towards CA. Our focus group discussions and interviews with key informants managed to elaborate why the non – adopters thought CA would lead them into serious problems. The issue of weeds came out as the main challenge in consistent with (Giller et al., 2009; Mashingaidze et al., 2012). This is not surprising given some authors have reported an increase in weed intensity and population under CA (Thierfelder et al., 2015b). The weeds can be controlled by mulching (Mtambanengwe et al., 2015) in addition to other control measures.

However, farmers require mulch levels > 4t/ha to suppress a wider spectrum of weeds (Mashingaidze et al., 2012). Additionally, research has shown that the application of pre - emergence herbicides can suppress various weeds species (Thierfelder et al., 2015b). However, asking resource poor farmers to buy these herbicides in Zimbabwe is like asking

someone to take a cow from someone who has none. The herbicides are not accessible and neither are they affordable to poor resource farmers in Zimbabwe (Thierfelder et al., 2015a) and southern Africa in general (Gowing & Palmer, 2008). On the other hand, some farmers expressed fear at the possible long term health impacts of using herbicides during the focus group discussions. In other studies, use of herbicides have been linked to breast cancer, abortions and reproductive complications in women while in men its linked to low sperm count, breast and prostate cancer (Nyanga, 2012). The perception of non-adopters has several policy implications.

It is critical to take note of the conditions that have been key to the successful implantation of CA in other countries and apply the appropriate ones to local situation. With this in mind the Government of Zimbabwe need to ensure farmers have access to affordable CA equipment and herbicides through capacitation of local manufacturers of equipment and herbicides so as to reduce labour requirements associated with drudgery under CA. In addition to this, majority of farmers believe that the yield benefits of CA are immediate, which is based on the information they receive from the proponents of CA. Rather extension agents need to tell farmers that CA benefits are not immediate and they may encounter yield penalty at the beginning. Therefore, agricultural extension agents need adequate training for them to get a deeper understanding of the mechanisms through which CA improves yields so as to avoid information asymmetry. They (extension agents) also need more training so that they can support farmers on what constitute full CA. Additionally, an increased number of government supported on farm demonstration trials will be required for farmers to observe and experiment with CA. Moreover, farmers need to be provided with requisite inputs and extension support during the early phases of adoption.

4.4.5 Factors determining the perception of non-adopters towards Conservation Agriculture

In order to identify the socio – economic variables that influenced the perception of the non-adopters towards CA, we performed a multinomial regression where perception was the dependent variable and the socio-economic attributes were the independent variables.

The overall perception of the farmers towards CA was influenced by age, gender, education, visit to demo sites and experience in CA and agriculture (Table 4.5). Majority of these are the same factors which had a significantly influence on the level of knowledge of the farmers about CA (Table 4.3). This goes to stress the importance of knowledge in shaping the perception of farmers towards CA as shown by the explanation given for experience in agriculture and gender.

4.4.5.1 Experience in CA

Experience in CA has a significant influence on the perception of the respondents towards CA. The experience in CA is expected to create favourable perception given that experience is the best teacher.

4.4.5.2 Gender

Gender of the respondent has a significant influence on the perception towards CA. Gender is expected to explain risk perception towards CA since women in Zimbabwe have mobility challenges which prohibit them from attending agricultural meetings (FAO, 2017). Additionally, whenever they attend such meetings, their participation will be low (FAO, 2017). The way CA was first introduced in Mudzi district may have shaped the initial perception of the farmers. In Mudzi, CA was introduced in 2004/05 by the Food and Agricultural Organization (FAO) and three Farmers Unions of Zimbabwe, targeting socio-economically empowered farmers who were already marketing maize.

Although targeting the poor might have pigeonholed CA as a technology for poor and not well-resourced farmers (Nyamadzawo et al., 2013), this stigma has been adequately addressed during extensive promotion of CA by different actors. However, targeting the poor was more appropriate and appealing given that CA seeks to eliminate an important barrier to cropping by the poor in the rural areas of Zimbabwe: inadequate drought power (Jones et al., 2005) Constraints such as access to inputs, markets and credit which were not part of this study were assumed to be inferred in the perception statements. However, the variables

will be analysed in our overall research theme that makes a critical assessment of conceptualizing CA adoption in Zimbabwe.

4.4.6 Correlation between Knowledge and Perception; Knowledge and Adoption and Perception and Adoption

Findings indicate that the knowledge variable was weakly but significantly correlated with a) perception and b) adoption. However, the perception variable was strongly and significantly correlated with adoption. A correlation coefficient less than 0.5 (Rs < 0.5) is regarded as low/weak (Sharma et al., 2011). Knowledge decreases the risk perception which explains the low but significant correlation between knowledge and perception. On the other hand, the weak but significant correlation knowledge and adoption and the very strong correlation between perception and adoption implies that (i) knowledge on its own cannot determine adoption as suggested by (Rao & Troshani, 2007), and (ii), if farmers have a favourable perception towards CA, chances of adopting are high. It also implies that closing the knowledge gaps only without addressing the key issues which affect the perception of farmers towards CA does not lead to adoption of CA. This is corroborated by Cheesman et al.(2017) who found that lack of knowledge is not a factor limiting CA adoption for farmers who had increased knowledge of CA due visit to some demonstration centres.

4.5 Conclusion and Recommendations

The majority of the respondents were women, with approximately the same proportion being above the age 50. Additionally, less than 10 % of respondents had received any formal agricultural training but majority (> 80 %) relied on agriculture for their livelihoods. The majority of the respondents had high knowledge level on the, social, economic and environmental viability CA and the explanatory variables were age, gender, level of formal education, visit to demonstration plots and experience with CA.

Majority of the non-adopters had low interest in CA and the explanatory variables of the indifferent perception were age, gender level of formal education, visit to demo sites, attendance to conferences, experience in agriculture and CA. We also found a very strong

correlation between perception of the farmer and his/her adoption intention but weak correlation between knowledge and perception and knowledge and adoption. This study confirms that knowledge (awareness) is not a barrier to adoption of CA. Thus intention to adopt seems to be constrained by negative perceptions towards CA. Therefore closing the perception gap very important to improve uptake of CA among smallholder farmers in Zimbabwe.

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CHAPTER 5: Conservation Agriculture Adoption Pathways among smallholder farmers in Zimbabwe

Abstract

Adoption of conservation is very limited in smallholder farming systems. Understanding the pathways of adoption could help understand the reasons for limited adoption of the practice. The objective of this article is to investigate the significant conservation agriculture adoption pathways by smallholder farmers in Mudzi District in Zimbabwe. Data was collected through a household questionnaire that was triangulated through focus group discussions, key informant interviews and personal observation. Demographic variables associated with significant adoption pathways were determined through ordered logistic regressions. The significant adoption pathways were: knowledge (mean score of 2.13) and compliance (mean score of 2.02). The explanatory variables of the knowledge pathway were: education, experience in agriculture, agricultural training and visit to demonstration centers while the gender of the household was the significant variable in explaining the compliance pathway. Therefore, any future promotion of conservation agriculture adoption should prioritize these two adoption pathway in marketing the technology. However, further research is necessary to determine the most effective adoption pathway in Zimbabwe.

Key words: *compliance, knowledge, demographic variables, ordered regression, Zimbabwe.*

5.1 Introduction

Access to information is critical for adoption of new technologies (Jack, 2011). This is true for conservation agriculture, which is regarded as knowledge - intensive and a diverse technology (Hamdy et al. 2016). However, smallholder farmers in sub-Sahara Africa have limited access to information (Ngwira et al. 2014). Simtowe et al. (2011) explored the determinants of knowledge on adoption of improved varieties of pigeon pea in Tanzania. Their results indicate that access to information related variables such as distance to extension officer, visit to demonstration centres, frequency of contact with extension workers, participation in participatory variety selection, distance to the major market, distance to the nearest agricultural extension officer and attendance to agricultural shows significantly influence the knowledge aspect. Torres, Daya, Ma, & Juvy. (2013) studied adoption and uptake pathways of genetically modified or biotechnology crops by smallholder, poor resource Filipino farmers. They found out that knowledge acquired though information sharing amongst farmers was the major factor that determined adoption or no adoption of the genetically modified crops.

When an individual adopts a technology based on one's cognitive ability, the behaviour is called acceptance which falls under the knowledge adoption pathway. Smallholder farmers in Agro Ecological Zones II and III of Zimbabwe, who voluntarily adopted conservation agriculture after realising its benefits are in the knowledge pathway group (Mazvimavi & Twomlow, 2009). On the other hand, acquired knowledge and experience about conservation agriculture determines the level of return to using the practice (Pedzisa et al. 2015). Cheesman, Andersson, & Frossard. (2017) have shown that a closed knowledge gap is

assumed where farmers would have practiced conservation agriculture for at least seven continuous years.

5.1.2 Compliance pathway

When farmers accept to use a technology in return for certain incentives such as seeds and fertilizers, associated with the technology, the adoption behaviour is often referred to as compliance (Carter et al. 2014). The pathway is influenced by gender as men are likely to rebel whereas women are more likely to take orders (Mazman et al. 2009). Brown et al. (2018) investigated pathways to intensify utilization of conservation agriculture by African smallholder farmers. They found that farmers may comply with incentives since they are constrained by lack of access to inputs. There are also situations in which individuals are forced to adopt certain technologies by organizations with no knowledge or prior information about the technology.

Majority of smallholder farmers adopt technology based on availability of external support associated with the use of the technology (Giller et al., 2009). The use of conservation agriculture under Operation Joseph and the humanitarian relief program in Zimbabwe can be placed under this umbrella compliance pathway of conservation agriculture adoption. Operation Joseph, which is regarded as the oldest conservation agriculture initiative in Zimbabwe, promoted the basin typology of the practice where farmers were given seed and fertilizers to use under a cereal legume rotation (Twomlow et al. 2008). Farmers who participated in the program were supposed to follow very stringent agronomic guidelines. Those households that failed to adhere to the rules were given three chances after which they were forced out of the program if they continued to disregard the guidelines of the program (Twomlow et al. 2008).

Conservation agriculture has also been advocated for by the United Kingdom's Department for International Development and the European Commission Humanitarian Aid Office under the Protracted Relief Program (Pedzisa et al. 2015). The beneficiaries of this program who were vulnerable households due to food production shortfalls (Mazvimavi & Twomlow, 2009), were given input subsidies (Anseeuw et al. 2012). Such initiatives have been blamed

for creating a donor dependency syndrome as participants relied heavily on the free inputs (Nhodo et al. 2011). Pedzisa et al. (2015a) reported that majority of the households that had adopted CA in Agro Ecological Zones II, III, IV and V of Zimbabwe abandoned it after the withdrawal of the input support scheme.

According to the later, the availability of inputs is a key recipe for overcoming adoption barriers of conservation agriculture particularly amongst resource constrained farmers. However, this is not sustainable in the long run. Derpsch, Lange, Birbaumer, & Moriya. (2016) have also reported cases of dis - adoption of conservation agriculture in Paraguay due to lack of ownership of the technology. Cases of dis-adoption of soil and water conservation technologies have also been reported in Ethiopia (Teshome et al. 2012). Baudron, Mwanza, Triomphe, & Bwalya. (2007) also reported cases of abandonment of conservation agriculture by some farmers in southern province of Zambia after discontinued input support.

All these cases of abandonment / dis adoption of conservation agriculture only goes to prove that lip stick adoption of improved agricultural technologies is a common feature of majority of poor resource farmers. IFAD (2016) argues that although incentives are necessary to kick start conservation agriculture uptake especially in the purchase of equipment, improved seeds, fertilizers and herbicides , this should done in conjunction with training so as not create the dependency syndrome among the recipients . On the other hand, it is critical for researchers to understand what triggers conservation agriculture adoption in different farming settings.

The practice was triggered by air pollution resulting from burning of crop residues in some parts of China (IFAD 2016). However, in the USA it was triggered by the dust bowls of the mid-1930s (Gomiero, 2016). However, increasing fuel , machinery and maintenance costs were the main reasons for triggering early CA initiatives in Zimbabwe (Andersson and Giller 2012). These cases point to an interesting scenario in which conservation agriculture maybe promoted to address national issues that might be in variance with agricultural related productivity challenges of the farmer.

5.1.3 Identification pathway

When an individual uses a technology because he/she wants to be associated with members in society who are already using the technology, this is referred to as identification and this becomes an associated behaviour (Jack 2013). Some farmers adopt new technologies after observing the benefits of the technology at their proximal neighbours. In reality, the concept of "copying from the best in the class" (Almond and Hainsworth 2005), which is part and parcel of free riding information access applies here. Identification pathway in technology adoption is more evident in less developed countries and the two main reasons for copying are lack of information and difference in decision making process (Pomp and Burger, 1995). On the other hand, female headed households are more likely to copy from others since they have little access to agricultural information. In addition, research has shown that men are less likely to copy from others (Venkatesh and Morris, 2000).

Individuals tend to adopt technologies in order to resemble others in the group – and this is termed normative isomorphism (Sastry, 1998). On the other hand, powerful farmers may encourage others to emulate practice of a group of farmers who are already practicing a technology, resulting in what is called mimetic isomorphism. Copying mechanisms are also important in situations where there are strong social network which allow members to give each other social and emotional support, companionship, time and information when they have challenges (Briggs, 1998). This could be critical in the first years of learning about conservation agriculture when farmers may experience loses.

A thorough understanding of the major conservation agriculture adoption pathways and the explanatory variables of each adoption pathway is critical to improve conservation agriculture uptake among smallholder farmers. This study uniquely addresses this aspect by focusing on Zimbabwe. Although conservation agriculture is important to countries throughout the world, this study specifically focuses on Zimbabwe because conservation agriculture is now a policy issue in the country and the agricultural sector is heavily prioritized in the country's Intended Nationally Determined Contributions submitted to the global Paris Agreement.

5.2 Material and Methods

5.2.1 Description of study area

The study was carried out in one District of Zimbabwe. Mudzi District is located in the north east part of the country. The district represents a typically high potential agro – ecological zone IIA. Granitic, nutrient deprived soils are the major soil types in his area (Jérôme, 2007). The area receives about is 1000 mm of rainfall per season (Soropa et al., 2015).

5.2.2 Research Design

A total of 360 smallholder farmers participated in the survey between March 2023 and April 2023. Out of the 360 participants who took part in the survey questionnaire, only 349 (97 %) fully completed the questionnaire and these were included in the final analysis.

5.2.3 Data collection procedure

A questionnaire was developed to collect demographic information of the smallholder farmers and to determine the CA pathway of adoption. While the first part of the questionnaire consisted of personal information, the second part contained statements on a 5- level Likert scale (1- "I strongly disagree" and 3- "neutral" and 5 – I "strongly agree") that were meant to summarise each of the adoption pathway variable: Knowledge. Identification and Compliance. The questionnaire was triangulated through focus group discussions, key informant interviews and personal observations. 360 participants (120 from each ward took part in the semi structured questionnaires. There was one focus group discussions per ward and a total of 12 participants, chosen based on age group, gender and social class took part in the group discussions.

Key informant interviews were conducted with participants from Department of Agriculture and extension, Department of Irrigation, Local authorities, Non-Governmental Organizations, agricultural input suppliers and buyers, lead farmers, political, traditional and religious leaders. All these methods were augmented through personal observations. Participation in

the survey was voluntary and members were told that only a summary of the results was to be published.

5.2.4 Data analysis procedure

Data was analyzed using STATA v 14.0 in order to determine significant adoption pathways, the fitness of the multinomial logistic model and demographic variables of each significant adoption pathway. On the other hand, information from the focus group discussions was analysed through thematic analysis and used to cross validate our findings.

The multi nominal logistic regression was most appropriate because our data violated certain requirements to do normal regression (the data does not form a linear pattern) and the dependent variables had more than two values (Mudzonga, 2012). The model was adapted from related studies (Knowler et al., 2014. The variables used in the multinomial logistic regression model are: age, gender, marital status, level of formal education, formal agricultural training, membership in agricultural associations , attendance to conferences and demonstration sites.

5.2.4.2 Decision Rule

Likert Model

$X = \sum x - n$: (1)

Where, X = weighted mean (mean score); X = Likert value; $\sum$ = summation and n = total respondents / sample size).

5.2.6 Challenges encountered during data collection

The major challenge encountered during data collection are presented below;

- Sample size generalizability
- Getting consent and approvals from relevant departments
- Busy schedules of participants
- Bureaucracy

5.3 Results

5.3.1 Demographic data

The majority (53 %) of the respondents completing the questionnaire were female , married and had received some form of formal education (Table 5.1).

Table 5.1: Gender, marital status, educational level, experience in agriculture and exposure of respondents to agricultural training

Variable	Mean	Std dev	Min	Max
Gender of HH (1 = male, 0 = female)	0.47	0.500	0	1
Marital Status of HH (1= single), (2 = married), (3 = on separation), (4 = divorced) and (5 = widowed).	2.57	1.243	1	5
Adult members (1 = 1 - 5), (2 = 6 - 10) & (3 = > 10)	1.22	0.461	1	3
Education level of HH (1 = none), (2 = primary), (3 = secondary), (4 = diploma) and (5 = degree)	1.99	0.782	1	3
Formal Agricultural Training of HH (0 = None), (1 = Yes)	0.93	0.263	0	1
Years of experience in Agriculture of HH (1 = Nil), (= 10)	2.95	1.023	1	4
Membership in Agricultural associations (0 = No), (1 = Yes)	0.96	0.190	0	1
Attendance to conferences (0 = No), (1 = Yes)	0.89	0.312	0	1
Attendance to demonstration centres (0 = No), (1 = yes)	0.85	0.370	0	1

5.3.1.1 Age distribution of the farmers

The age distribution of the respondents is indicated in Table 5.2

Table 5.2 : Age distribution of the respondents

Age group	Frequency	Percentages
0 < 21	1	0.3
21 – 30	21	6
31 – 40	67	19.2
41 – 50	111	31.8

Majority of the respondents were in the 41 – 50 years category (Table 5.2)

Table 5.3: Summary statistics of the hypothesis

Hypotheses pathway	Mean	Std error	Remarks
Knowledge Adoption → Adoption	2.13	0.043	Accepted
Compliance → Adoption	2.02	0.043	Accepted
Identification → Adoption	1.82	0.042	Accepted

5.3.3.2 Socio demographic factor affecting significant adoption pathways

Table 5.4 shows the regression results of the knowledge pathway to adoption while Table 5.5 shows that compliance adoption pathway. The log likelihood Ratio Chi^2 was 125.937 and the log likelihood was -282.4435 for the acceptance typology adoption pathway with a Pseudo R^2 of 0.166 meaning that the model gave a very good fit to the data. The socio demo graphic variables that significantly ($P < 0.05$) influenced the knowledge pathway were educational level, agricultural training, experience in agriculture and visit to demonstration centres.

Table 5.4: Determinants of the knowledge pathway of CA adoption

Variable	Chi - square	P - value
Age	12.793	0.119
Gender	3.496	0.174
Marital Status	20.622	0.108
Education level	36.570	0.0001*
Agricultural Training	36.570	0.004*
Master Farmer Training	11.120	0.442
Experience in agriculture	1.632	0.024*
Belonging to a social group	10.012	0.048*
Attendance at conferences	3.936	0.140
Agricultural cooperatives	14.704	0.23

Likelihood Ratio Chi^2 125.937; Pseudo R^2 0.166

Log Likelihood - 282. 4435; Note: * significant at 5 % probability level.

The log likelihood Ratio Chi^2 was 132.663 and the log likelihood was -284.566 with a Pseudo R^2 of 0.173 for the compliance pathway to CA adoption implying the model gave a very good fit to the data. The socio demographic factor that significantly ($P < 0.05$) explained the compliance pathway was gender of the household head (Table 5.5).

Table 5.5: Determinants of the compliance pathway of CA adoption

Variable	Chi-square	P-value
Age	14.05	0.081
Gender	3.208	0.007*
Marital Status	20.92	0.201
Education level	3.628	0.459
Agricultural Training	32.76	0.365
Master Farmer Training	3.067	0.216
Experience in agriculture	2.112	0.348
Labour source	1.019	0.322
Attendance at conferences	6.416	0.601
Agricultural cooperatives	3.671	0.400

Likelihood Ratio Chi^2 132.663; Pseudo R^2 0.173;

Log Likelihood -284.566; * significant at 5 % probability level.

5.4 Discussion

5.5.1 Socio-demographic variables

The results indicate that majority of those who completed the survey were women, were married and had received some form of formal education. Earlier studies have revealed that

women in Zambia and Zimbabwe have challenges in accessing agricultural extension information (Mango et al. 2017). The results also indicate that majority of the households respondents had completed at least primary education which is critical for adoption of CA since the practice is knowledge intensive (Cheesman et al . 2017). On the other, marital status is critical in decision making. Previous studies have indicated that married couples can make better decisions if they share information with their partners (Obayelu et al . 2014).

5.4.3 Adoption Pathways

5.4.3.1 Knowledge pathway to adoption

The results indicate that knowledge acquisition is a significant pathway to adoption of conservation agriculture. Knowledge is critical in agricultural technology adoption where farmers are not involved in the generation of the technology (Jabbar et al. 1998). Educational level had a positive significant impact on the knowledge pathway to conservation agriculture adoption . This is consistent with earlier studies which indicate that an educated farmer is able to evaluate the benefits of a new technology and make decisions without external forces (Ntshangase et al. 2018). This is not surprising given that education can change the perception of individuals towards a technology through a better analysis of pros and cons of using a technology (Marra and Ssali, 1990).

In Zimbabwe, adoption trends changed when FAO changed tactics and promoted conservation agriculture to those farmers who already understood the benefits of conservation agriculture (FAO 2014) as opposed to the compliance pathways that had been introduced in the 1990s at the Hinton Estates (Harford et al. 2009) and during the humanitarian relief program which saw some farmers dropping out when the input incentive was discontinued in Zimbabwe (Mazvimavi, 2011).

The case of abandonment is also supported by findings by Pedzisa et al. (2015), who found out a negative relationship between continued input support and conservation agriculture abandonment among smallholder farmers in Zimbabwe. Due to the differences in heuristics between older and younger people (Besedeŝ et al. 2012), it is therefore expected that older people can easily associate conservation agriculture with improved yields just like

associating " nurse" with "white" implying that they may initially have a hedonic behaviour towards conservation agriculture with regards to its ability to improve yields.

On the other hand, experience in agriculture and agricultural training all had a significant influence on the knowledge adoption pathway. This is supported by Haggblade and Tembo (2003) who found out that agriculture training and experience are important in managing agricultural innovations. The visit to demonstration centres influenced the knowledge pathway to conservation agriculture adoption. This is not surprising given that Mazvimavi et al. (2011) found that demonstration centres enable impulsive adoption through observing benefits of conservation agriculture through learning from others.

From the foregoing discussion, government agricultural programs that are meant to increase access to low credit by smallholder farmers need to incentivise CA farmers. However, extension agents need to ensure that the plots under conservation agriculture and those not under conventional system have the same management applications for example time of planting, weeding and application of fertilizers. This will enable farmer to make informed decisions based on experience and observations.

5.4.3.2 Compliance adoption pathway

The results show that farmers in the Mudzi District adopt conservation agriculture through the compliance pathway. This is not surprising given that the largest conservation agriculture initiative in Zimbabwe by some Non-Governmental Organizations, focused on food insecure households whom they provided with fertilizers and seeds. Funding for this initiative came from the Department of Internal Cooperation with the International Crop Research Institute for the Semi-Arid Tropics providing technical assistance to ten Non-Governmental Organizations who carried out field work. Under the program, beneficiaries across 13 districts in semi-arid Zimbabwe received free agricultural inputs. The provision of free inputs saw an increase in the number of farmers practicing conservation agriculture from 20 000 in 2006/07 to 120 000 in the 2009/10 cropping season (Mazvimavi, 2011).

This figure rose to 300 000 by the 2010/11 cropping season of which about 40 % of this figure had adopted conservation agriculture without the agricultural input support

(Marongwe et al ., 2012). The compliance pathway to conservation agriculture adoption is considered weak as farmers might abandon conservation agriculture when the provision of free agricultural inputs is discontinued (FAO 2014). Participants in the focus group discussions indicated that "lipstick" adoption is common in Mudzi District. When the FAO realised the challenges with the input pathway of adoption, they changed tactics to focus on a small number of farmers who were convinced of the benefits of conservation agriculture.

They set up demonstration centers in nearby areas; tested and introduced tailor made equipment to reduce labour burden of conservation agriculture on planting and application of fertilizers. This lead to a marked increase in the number farmers practicing the technology. The demonstration centers are good recipe for adoption of conservation agriculture given the visual – centric nature of human beings. However, the proponents of conservation agriculture need to embrace the inherent indigenous knowledge that are compatible with conservation agriculture instead of transferring external knowledge to the farmers. If proponents of the practice can incorporate local knowledge , show that conservation agriculture plots can get better yields than conventional plots and prove that it is more resilient to climate variability and change than conventional plots, then the message scientist spread about the need to adopt conservation agriculture becomes candid.

The gender variable was significant in explaining the compliance pathway to conservation agriculture adoption. Studies have shown that women are more likely to take orders compared to men who are likely to behave in a rebellious way (Venkatesh et al. 2000). Put it differently, women more than men are more likely to accept a new technology based on availability of facilitating conditions in using a new technology (Hu et al. 2010).

5.5 Recommendations

5.6 Conclusion

The main conclusion to our study is that the knowledge and compliance pathways were the major adoption pathways of conservation agriculture by smallholder farmers in Zimbabwe.

The significant explanatory variables of the knowledge pathway were : education level, experience in agriculture, agricultural training and visit to demonstration centers while the gender of household was significant in explaining the compliance pathway . There is need for further studies to determine the most sustainable adoption pathway of the technology among smallholder farmers .

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CHAPTER 6: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

The previous chapter presented, analysed and discussed data collected in the surveys in a bid to answer the various objective questions. This chapter is made up of the summary, conclusions and recommendations from the study bearing in mind why the research was conducted. The chapter is of importance as it provides a room for not only concluding the research but also to give recommendations and the suggestions for further study. In this chapter the researcher makes inferences and conclusions of the research using the information obtained from the findings as discussed in chapter four. Appropriate reference will be made to sections of this document in support of the conclusions drawn. Reference will be made to findings of this study to support of the conclusions drawn.

The study was is pinned by the critical role that Knowledge, Attitudes and Perceptions (KAPs) can play to understand the behavioural intention of farmers to adopt CA. It also shows the need to understand the personal, personality, social – economic characteristics which can affect KAPs and hence CA adoption intention of smallholder farmers. KAPs looks at the mind sets and behaviour - "orgware" (Herrero 2003) and how these must be modified to accommodate CA. It is however important to mention that majority of people cherish to change to a system of greater efficiency in terms of labour. Therefore, the mind sets and behaviour of the farmers can be changed through access to CA equipment. The access to CA equipment can be analysed through the 5As framework - Availability, Awareness, Accessibility, Affordability and Acceptability (Delve et al. 2004).

The study adopted the mixed methods approach. Questionnaires were used to generate data. The following are the measures that the researcher used to analyse both the qualitative and the quantitative data for the study.

Qualitative Data Analysis: data was analysed with the use of thematic and content analysis. After conducting interviews which were recorded on the phone, some of which were noted down. The researcher came up with themes from the findings that were generated. Upon deriving the themes from the findings of the study, the researcher further analysed the content in each and every theme.

Quantitative Data Analysis: data obtained with the use of the questionnaire research instrument was analysed with the use the Statistical Package for Social Sciences (SPSS). Upon completion of the data collection process, the researcher cleaned and sorted the data. The questionnaires that were not fully filled were excluded from analysis. Data was then coded and put into the SPSS software where is was analysed with use of various analytical methods. Some of these include descriptive analysis relating to mean, standard deviations and frequency. Inferential analysis was also carried out in which the correlations and regression analysis were carried out to determine the relationship between variables. Data was presented with the use of tables and figures.

6.2 Research summary

The study was based on evaluating the uptake of Conservation Agriculture practices among smallholder farmers. A case for Mudzi District in Mashonaland East Province. The objetcives of the study were; to investigate the behaviour of smallholder farmers towards adoption of CA, to investigate the significant pathways of CA adoption among smallholder farmers, to investigate factors affecting access to CA equipment by smallholder farmers and to investigate the factors affecting access to market by smallholder farmers.

6.3 Conclusions

This study dealt with conceptualisation of conservation agriculture adoption among smallholder farmers using Zimbabwe as a case study. This is a very important topic given

the need to search for new agricultural innovations that can sustainably increase agricultural productivity without increasing the environmental footprint of agriculture. The main focus of this thesis was to get an in-depth understanding of the socio - economic and non - socio economic factors that result in piecemeal adoption of conservation agriculture despite decades of research and promotion by different entities in the country. To achieve this, a pre - tested household questionnaire was administered to 360 participants in Mudzi District Zimbabwe. The questionnaire was triangulated through focus group discussions, key informant interviews and personal observations. Household survey data was analysed using Statistical Package for Social Scientists and the Statistical Analysis Software. However data from focus group discussions and key informant interview was analysed through thematic analysis.

Literature review revealed the complexity of measuring adoption of conservation agriculture. Firstly, most of the reported adoption figures are measured under a supported project in which farmers are given inputs such as seed and fertilizers as incentives for adopting the technology. Secondly, majority of farmers in southern Africa and especially Zimbabwe rarely adopt the full package and yet the full benefits of the technology are obtained upon meticulous and simultaneous application of all the principles.

Results in Chapter four show that although majority of the respondents had not received any formal agricultural training , agriculture is their main source of income and livelihoods. In addition, we also found out that a very small proportion of the smallholder farmers had more than 10 years of experience with conservation agriculture, despite more than a decade of CA promotion in the country. However, notwithstanding the low level of experience with the technology, the smallholder farmers had high knowledge about social, economic and environmental benefits of CA. In spite of this seemingly high knowledge about CA , our results suggest that the perception of the farmers had a more important role to play in the adoption of CA. Weather, this is applicable to all smallholder farmers in Zimbabwe, or is only specific to the study area will need to be addressed through further empirical investigations through disaggregating the data to each specific location. However, from the

current study, we can safely conclude that closing the perception gap is necessary in order to improve uptake of conservation agriculture among smallholder farmers in Zimbabwe.

Results in Chapter five indicate that smallholder farmers in Zimbabwe adopt CA through the knowledge and compliance pathways. The adoption of conservation agriculture in response to conditional handouts of agricultural inputs (compliance) is well documented. While it cannot be disputed that farmers may discontinue or abandon the technology once the input scheme ends, it is also critical to give early adopters the necessary support since benefits of CA will take some three – five seasons to accrue. Some studies have also reported yield penalties in the first few years of CA adoption. The reasons for the yield penalties are well documented in several adoption studies. On the positive side however, farmers in the study areas adopt CA through the knowledge pathway, meaning that information is not a barrier to the adoption of CA. The chapter recommends that future studies are required to determine the most effective adoption pathway of conservation agriculture among smallholder farmers given our reservations with the compliance pathway.

Results in Chapter five indicate that majority of the smallholder farmers could not afford to buy conservation agriculture equipment; the equipment was not available in local shops; they were geographically located in areas with low access to conservation agriculture equipment and in cases where the equipment was available, farmers were not satisfied with the services. The major highlight of this chapter is that it made a significant contribution to the application of the 5As framework to classify the access to equipment objectively. This might inform academics and policy makers about the challenges in accessing conservation agriculture equipment by smallholder farmers and at the same time capture the salient non-socio – economic factors in the adoption of conservation agriculture.

It is therefore concluded that the behaviour intention of the farmers to adopt conservation agriculture is shaped more by the perception as compared to the knowledge level of the farmers. On the other hand, farmers adopt conservation agriculture through the knowledge and compliance pathways. Also the non-socio - economic factor affecting access to conservation agriculture are affordability, accessibility , acceptability and availability while the

socio economic factors affecting access to equipment are age, level of formal education, experience with agriculture and area under conservation agriculture. Farmers had low level of participation in agricultural markets. The access to markets may be enhanced through improved access to extension and inputs and belonging to an agricultural groups.

6.4 Policy implication and recommendations

6.4.1 Implications

The implication of these findings is that closing negative perception gaps, using appropriate pathways of adoption, improving access to conservation agriculture equipment and linking farmers to agricultural markets are key drivers of adoption of CA among smallholder farmers in Zimbabwe. On the other hand, proponents of CA are advised to consider the socio-economic as well as the non - socio - economic attributes of the beneficiaries when marketing the practice.

Addressing barriers to the adoption will improve the sustained uptake of the practice and boast farm productivity, thereby increasing food and income security of smallholder farmers who are vulnerable to the vagaries of climate change. We believe that this research has made significant contribution to the complex field of adoption of conservation agriculture by reducing a complex adoption model into smaller manageable and measurable variables and specifically bringing in the non – socio economic attribute into the adoption matrix.

6.4.2 Recommendations

- There is need for proponents of CA to establish demonstration centres in each village so as to promote experimental learning as this might decrease their indifferent perception towards the technology.

6.5 Areas for further research

1] Future research need to focus on the most effective and sustainable CA adoption pathway.

2] Future research need to explore geographical variations in barriers to adoption of CA by disaggregating data for each site.

3] Future research need to capture the relevance importance of each of the 5As in determining access to conservation agriculture equipment by smallholder farmers in different agro ecological zones so as to recommend targeted interventions.

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APPENDIX I: QUESTIONNAIRE

My name is Robert Jamu, I am a student Bindura University of Science Education pursuing Master of Science Degree in Food Security and Sustainable Agriculture. I request that you assist me in my studies by completing this questionnaire. Your participation is voluntary and you can withdraw at any time without penalty. All data will be kept confidential, and no identifying information is stored. By completing the questionnaire , you indicate that you voluntarily participate in this research. If you have any concerns, please contact me. My details are provided below.

+263 77 228 3554

SECTION A: DEMOGRAPHIC INFORMATION

A1. Age of the Household head (Decision maker) …… (Years)

A2. Gender of the Household Head (Decision maker)

1= Male ☐ 2 = Female ☐

A3. Level of education of the household head

1 = No formal education 2 = Primary 3 = Secondary 4 = University

5= Other (specify) _____

A4. Do you know how to read? Yes……. No …….

A5. People living in homestead

Children (0-17) Adults (18-59) Elderly (>60)

A6. Do you belong to a farmers group?

1 = Yes ☐ 0 = No ☐

A7. What are the major sources of household income?

Choose three most important.

a. Crop production; b. Livestock production ; c. Business; d . Casual labour; e . Remittances;

f. Employment; g. Others (specify)……..

SECTION B: EMPOWERMENT

B1. Have you attended any type of training organized by CA promoters?

☐1 = Yes, ☐ 2 = No

B2. If yes, please provide the following information

Type of training	Received?		Type of skills gained (Recall)	Ever used the skills gained?		Are you still practising the gained skills?	
	Yes	No		Yes	No	Yes	No
1. Land preparation							
2. Seeding							
3. Weed control							
4. Cover Crops							
5. Harvest							
6. Environment conservation							

7. Farmers Group dynamics							
8. Produce marketing							
9. Agribusiness/Entrepreneurship							
10. Other:							

B3. If you have not been able to use the knowledge and skills gained, list the three major reasons/ constraints?

(a) ……..…….....……

(b) …… (c)

…….....

SECTION C: CHALLENGES OF ADOPTION

Score the challenges facing the adoption of CA technologies (Score in a scale of 1 to 5, where 1 is the least challenging and 5 is the most challenging) as listed below.

	Challenges facing adoption of CA technologies	Score
1.	Fixed mind-set of agriculture leaders, extension agents and farmers	
2.	Lack or inaccessibility of appropriate CA equipment	
3.	High costs of CA tools and equipment	
4.	Wide spread use of crop residues for livestock feed and fuel	
5.	Burning of crop residues	
6.	Lack of knowledge about the potential benefits of CA	
7.	Lack of government policy support for CA –enabling environment	
8.	Traditions and culture	
9.	Availability of cover crops seeds	
10.	Others (specify) ….	

SECTION D: OVERALL IMPACT

How did the CA interventions (in the project you were involved in) impact on the below listed areas? (Use 1 = Improved, 2 = Static and 3 = Decreased)

Aspects under CA	1=Improved, 2= Static & 3= Decreased
Food security	
Income	
Health and nutrition	
Assets	
Environment	
Social	
Gender disparity	

How has the CA impacts been realized in terms of timelines (Use 1=short term, 2=medium

Aspects under CA	1=Short term, 2=Medium term & 3=Long term	Beneficiary (M=Male, F=Female or B=Both)
Food security		
Income		
Health and nutrition		
Assets		
Environment		
Social		
Gender disparity		

What are the top 3 benefits that can be attributed to the CA projects?

1=Very reliable, 2=Somehow reliable, 3=Less reliable, 4=Not reliable at all

Description	Rank the top three in order of importance (1 = most important, 3 least important)
1. Increase revenue	
2. Improving food security	
3. Purchase of assets/goods	
4. Increases in CA inputs and service provision and usage	
5. Policy changes supportive of CA	
6. Start a new business (specify):	
7. Increase in awareness, knowledge, skills	
8. Changes in community capacity	

SECTION E: POLICY INTERVENTION ON CA

Are you aware of any policy intervention that governs the CA technologies?

1=Yes ☐ 2=No ☐

If yes, has it worked and what changes has it brought?

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

What kind of policy was it?

.....
.....

Do you understand the policy?

1=Yes ☐ 2=No ☐

SECTION F: AFFORDABILITY AND SUSTAINABILITY

How durable are the adoption of CA practice?

Type of technology /practice	**Durability** (1=Durable 0=Not durable)	**Sustainability** (1=Sustainable 0=not sustainable)
Direct planting in lines		
Sow in hole with machete / stick		
Jab planter		
Early sowing just after slashing		
Mulching		
Uprooting weeds (not cutting)		
Early weeding		
Set firewalls		
Slash cover crops at flowering stage		
Soil permanently covered		
Leave crop residue in field after harvesting		
Crop rotation		
Inter cropping		
Cover crop during dry season		
Use manure for fertilizer		
Use crop residues for livestock feed		

What are your recommendations towards the adoption of CA practices by small holder framers?

……
……
……

THANK YOU VERY MUCH FOR YOUR TIME AND COOPERATION

APPENDIX II: FOCUS GROUP DISCUSSIONS GUIDE

Interview Guide for the Focus Group Discussion

1. Have you ever heard of smallholder farmers non-adopting CA?

2. If "Yes" to the above question, which CA tillage are the smallholder farmers non-adopting?

3. State reasons/factors you think contribute to non-adoption of the named CA tillage in question two among smallholder farmers.

4. What possible solutions do you think can help minimize/reduce non-adoption of CA?

5. Are there any benefits that smallholder farmers attain after non-adopting CA?

6. Are there incentives given to those practicing CA?

7. What types of incentives are given to the smallholder farmers practicing CA?

8. Do the smallholder farmers who non-adopt CA hope to readopt CA?

APPENDIX III: INTERVIEW GUIDE

Interview Guide for the Key Informants

1. Have you ever heard of smallholder farmers non-adopting CA?

2. If „Yes" to the above question, which CA tillage are the smallholder farmers non-adopting?

3. State reasons/factors you think contribute to non-adoption of the named CA tillage in question two among smallholder farmers.

4. What possible solutions do you think can help minimize/reduce non-adoption of CA?

5. Are there any benefits that smallholder farmers attain after non-adopting CA?

6. Are there incentives given to those practicing CA?

7. What types of incentives are given to the smallholder farmers practicing CA?

8. Do the smallholder farmers who non-adopt CA hope to readopt CA?