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CONCEPTUALISING CONSERVATION AGRICULTURE ADOPTION IN ZIMBABWE

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CONCEPTUALISING CONSERVATION AGRICULTURE ADOPTION IN ZIMBABWE

By

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PREFACE

This research, which was supported by the National Research Foundation of South Africa, was completed in the discipline of Crop Science, School of Agricultural, Earth and Environmental Sciences, College of Agriculture, Engineering and Science, University of KwaZulu Natal, Pietermaritzburg Campus, South Africa.

The content of this work has not been submitted to any other university. The results reported here in are based on the investigations of the author, except where the work of others is duly acknowledged in the text.

………………………………………………………………………………………..

Signed: Professor Paramu Mafongoya (Supervisor)

Date: …………………………………………………….

DECLARATION

I, Mugandani Raymond declare that:

i. The research reported in this thesis is the result of my original investigation, except where otherwise indicated or acknowledged.

ii. The thesis has not been submitted to any other university, either in part or in full.

iii. This dissertation does not contain other peoples' information, or data, pictures, graphs unless specifically acknowledged as being sourced from other persons;

Mugandani Raymond…………………………………………………………..

Date…………………………………………………………………………..

As research supervisor, I agree to submission of this thesis for examination

Professor P. Mafongoya (Supervisor) ………………………………………….

Date………………………………………………

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ABSTRACT

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 Chivi, Murehwa and Mutoko districts. A pre - tested questionnaire was administered to three selected wards in each of the three 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. Our 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, we 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. We also found out 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 also investigated access to equipment by smallholder farmers. The results indicate that the respondents had low access to conservation agriculture equipment (mean score of 1.72). The respondents indicated that availability, affordability accessibility and acceptability were the main non - socio - economic constraints to accessing conservation agriculture equipment. On access to agricultural markets, we found out that farmers had low level of access to markets (mean score of 1.814). Gender of household head (β = - 1.3196) and age of household head (β = - 0.63198) all had inverse but significant relationship with access to agricultural markets by the farmers. However, access to inputs (β = 2.3893), access to extension (β = 1.21) and belonging to agricultural groups (β = 0.887) all had positive and significant relationship with access to agricultural markets by the smallholder farmers. 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.

CHAPTER 1: BACKGROUND OF THE STUDY

1.1 Rationale of the study

The adoption of Conservation Agriculture (CA) is increasingly becoming critical to sustainably increase agricultural productivity in southern Africa. Adoption refers to a stage when an individual or organization selects and use a certain technology (Onyenekenwa 2010). On the other hand, CA is defined as any farming systems that involves simultaneous application of three interrelated principles of minimum soil tillage, permanent soil cover using crop residues or mulch and diversified crop rotations and intercropping (Brown et al. 2018). CA can enhance food security, restore soil fertility (Mafongoya et al. 2016), help farmers to utilise early planting windows and address shortage of draft power in communal areas (Baudron et al. 2015). The practice is also important in sustainably increasing agricultural productivity without increasing the carbon foot print of agriculture (González-Sánchez et al. 2016). It is suitable for Zimbabwe where crops yields are constrained by low soil fertility, exacerbated by increase in frequency and severity of droughts (Makuvaro et al. 2017).

Reduced tillage, which is one of the principles of CA was prompted by the "Dust Bowls" in North America (Hobbs et al. 2008). Whereas high costs of fuel, machinery procurement and maintenance triggered the early adoption of reduced tillage practices in Zimbabwe (Andersson & Giller 2012), present CA practices in Zimbabwe, which started in 2003 was prompted by the need to increase food security of vulnerable households. (DFID 2009). The visibility and promotion of such an initiative was made possible by collaboration among the Food and Agriculture Organization (FAO), Non-Governmental Organizations (NGOs), Research Institute for the Semi–arid Tropics (ICRISAT), International Maize and Wheat Improvement Centre (CIMMYT), government and academia (Pedzisa 2016). However, CA adoption in Zimbabwe is very limited with an estimated 8.3 % (as at 2014) of the total arable area under CA (Richards et al. 2014). In addition, cases of farmers not adhering to all the three principles of CA have been well documented in Zimbabwe (Pedzisa et al. 2015). The reasons for poor adoption remains a black box for policy makers and academics. Although there is substantive research on the benefits of CA in sub-Sahara Africa (SSA) and Zimbabwe (Nyagumbo et al. 2017). However, little research has been undertaken to understand: the behaviour of smallholder farmers towards CA, CA adoption pathways; determinants of access to CA equipment and access to markets by smallholder farmers.

1.2 Problem Statement

Policy makers, academics and other stakeholders need to understand why the adoption of CA is very low despite several benefits of CA in improving agricultural productivity (Giller et al. 2015); increasing water infiltration and storage (Kassam et al. 2014). CA can also help reduce: the carbon footprint of agriculture (Busari et al. 2015); pesticides, machinery and fertilizer use (Biala and Terres 2007). The practice also offers numerous ecosystem services in addition to the restoration of degraded lands (Kassam et al. 2015).

Globally, about 11 % of arable land is under CA (González-Sánchez et al. 2016). In Africa, the total area under CA is 1.22 million ha which is equivalent to less than 0.3 % of the global area under CA (Kassam et al. 2014). Farmers in SSA have been slow to adopt CA (Fisher et al. 2018). Specifically, less than 1 % of the total arable land is under CA in the region, with a total of 600 000 farmers practicing some typology of CA (Hove et al. 2011). However, these figures might be misleading given that some farmers who use one or two of the three principles of CA are often countered as CA farmers (Giller et al. 2015). Let alone for smallholder farmers in Africa and Asia, adoption inducements are provided in the form of inputs, which is risky considering that "lipstick" adoption is possible under these circumstances.

The typology of CA being promoted in Zimbabwe is based on three key pillars: minimum soil disturbance; diversified crop rotations and permanent soil cover (Zira et al. 2013). However, in practice what is referred to as CA in Zimbabwe is the simultaneous application of winter weeding, use of planting basins, leaving crops residues on the surface, judicious application of manure and fertiliser, early weeding and inclusion of legumes in rotation even if cereals are the main crops (Pedzisa 2016). However farmers do not apply all these components at the same time.

The low adoption of CA technology in SSA and Zimbabwe in particular is a paradox given the potentially huge environmental and economic benefits of CA in a region that has the most undesirable conditions to improve agricultural yields. Much of the promotion and research has focused on the technology itself while there is dearth of literature at the behaviour of farmers towards CA, access to equipment, CA adoption pathway and access to markets by smallholder farmers.

1.3 Importance of the study

Sustainable agricultural production systems have a global interest given the projected increase in food demand by 2050 due to: increase in population (FAO 2009); changes in consumption patterns (Gomiero 2016); increased demand for bio fuels (González-Sánchez et al. 2016) and the need to reverse land degradation and address the climate change challenge (Lal 2014). The highest demand for food is expected to be in SSA, a region that is expected to contribute half of the additional 2 billion people to the world population by 2050 (van Ittersum et al. 2016) but yields in the region have stagnated or fallen in some cases (Deepak et al. 2013). Climate change hot spot areas in SAA are further projected to have yield decline by 14.6 %, 11.5 % and 32.8 % for maize, rice and wheat respectively by 2050 (Lal 2014). The challenge is worsened by endemic land degradation (mainly soil nutrient mining) in the region (Toenniessen et al. 2008). On the other hand, conditions for improving agricultural productivity are more challenging than any other region in the globe: SSA depends on rain fed agriculture, which is projected to exhibit high spatial temporal variation (OECD/FAO 2016). Only 4 % of the land is irrigated, there is scarcity of labour (Toenniessen et al. 2008), the rural population is widely dispersed, market access is poor, there is little mechanization (Toenniessen et al. 2008) and there is limited uptake of new agricultural technologies In fact, increase in agricultural production in Zimbabwe has come from extensification especially into marginal areas as compared to intensification (Baudron et al. 2012). Extensification, leads to land degradation which increases exposure to climate variability and extreme weather events thereby creating a vicious cycle of hunger and poverty in smallholder farming systems (Vanlauwe et al. 2014).

There is huge potential to increase agricultural productivity and close the yield gap in the region through adoption of sustainable agricultural practices. Policy makers and developmental agencies in Africa still prioritise investment in smallholder farmers as the engine for economic transformation and poverty eradication (Allinace for a Green Revolution in Africa 2014) and adoption of sustainable practices in the face of increasing exposure to climate risks.

Conservation Agriculture (CA) has long been recognised as one option of sustainable agricultural practices in view of climate change (Grabowski et al. 2016). CA has been widely promoted by developmental partners such as the FAO, CIRAD, CIMMYT, ICRISAT and the African Conservation Tillage Network (Corbeels et al. 2014). The overall goal of such a practice is to improved resource use efficiency by conserving soil and water so as to minimise use of external inputs especially herbicides and fertilizers. It is suitable for areas constrained by low soil fertility, frequent droughts and moisture stress. (Thierfelder et al. 2014).

CA has the potential to address soil degradation resulting from practices that deplete soil organic matter and threatens the livelihoods of over 2 billion people worldwide (Barbut and Alexander 2015). The technology is based on three pillars: minimum soil disturbance, crop rotations and diversification and maintenance of permanent cover (Zira et al. 2013).

There is substantial literature documenting the benefits of CA in SSA and Zimbabwe (Thierfelder et al. 2017). Most of the benefits of CA adoption arise as result of reduced costs of machinery, fuel and labour, increased yields, early planting, reduced soil degradation (Giller et al. 2011). However, despite its huge potential in SSA, there is limited adoption of CA in the region compared to other areas of the globe. While south America has about 47 % of its arable area under no till, SSA has about 1 % of arable land under CA (Hove et al. 2011) while Zimbabwe has about 8.5 % of total area under CA (Richards et al. 2014). This is despite more than two decades of extensive research, marketing and promotion. The huge discrepancy between benefits of CA and low levels of adoption (Grabowski et al. 2016) calls for more research to understand challenges in adoption.

1.4 Hypotheses

1. Smallholder farmers' behaviour towards CA is shaped by their knowledge and perceptions.

2. There are several pathways for CA adoption among smallholder farmers.

3. Smallholder farmers' adoption of CA is constrained by the affordability, availability, accessibility, acceptability and level of awareness of farmers about more efficiency CA equipment.

4. Smallholder farmers' adoption of CA is constrained by access to markets.

1.5 Objectives of the study

The overall objective of this study was to explore the factors that affect adoption of CA by smallholder farmers in Zimbabwe.

1.5.1 Specific objectives

1. To investigate the behaviour of smallholder farmers towards adoption of CA

2. To investigate the significant pathways of CA adoption among smallholder farmers

3. To investigate factors affecting access to CA equipment by smallholder farmers

4. To investigate the factors affecting access to market by smallholder farmers

1.6 Conceptual framework

Figure 1.1 outline the conceptual framework for this study. It 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).

1.6.1 Role of knowledge, attitudes and perception in technology adoption

When an agricultural innovation is introduced to an individual, the first phase of the adoption process is the acquisition of knowledge about the innovation with regards to how it's applied, the potential yield and environmental benefits, the possible risks and the cost associated with the technology (Meijer et al. 2015). The level of knowledge about the attributes of the technology will form the basis for the perceptions and attitude of the individual farmer towards the technology. Perception is the opinion or impression that farmers have about the innovation which is dependent upon the needs and prior experiences. On the other hand, the attitude is the summary evaluation of an object which is based on the knowledge and perceptions (Meijer et al. 2015). A positive attitude towards an agricultural innovation is posited to influence a positive attitude towards adoption or behavioural intention.

There are a few examples of publications from SSA that explores how the attitude and perceptions of smallholder farmers are linked to uptake of agricultural practices, particularly in agroforestry. In a study on farmers' perceptions of tree death, pest outbreak and management practices in agroforestry systems in Malawi, Mozambique and Zambia, Sileshi et al. (2008) revealed that farmers perceived insects as the main cause of mortality of tress while droughts, bushfires and livestock browsing were regarded as minor variables. They then found out that the gender, education level and years of experience with tree species of the household were significant variables in explaining the perception of farmers towards tree death. From a study in West Africa, Douthwaite et al. (2002) revealed that scientists had more positive perception about *Mucuna pruriens* cover crops and alley cropping compared to farmers. Whereas scientists believed that *Mucuna pruriens* was more attractive to farmers due to its ability to improve soil fertility, farmers were more attracted to *Mucuna pruriens* because its ability to control weeds. If these different perceptions are not fully addressed because of information asymmetry, adoption of these agroforestry systems might be piecemeal (Meijer et al. 2015). On the other hand *Mucuna pruriens* was easy to promote in West Africa compared to alley cropping since the latter was simpler and easy to adapt to local situations while the alley cropping was virtually new (Douthwaite et al. 2002.

The knowledge, attitudes and perceptions of an individual depends on extrinsic variables such as characteristics of the: farmer, external environment, and the innovation. The characteristics of the innovation include: economic, social and environmental viability/benefits and the cost associated with the use of the innovation. The characteristic of the farmer that influence KAP are the personal, socio-economic, personality and status characteristics. On the other hand, the characteristics of the external environment include: geographical location, cultural norms and values and government policy. Concerning the characteristic of the innovation, the goal of the farmer is important. Farmers are interested in technologies that can increase food and income security in a changing climate, restore or reduce land degradation, reduce pest and disease outbreak and reduce cost of production.

Several barriers (inhibiting factors) have been identified in adoption of CA. Some of the barriers include: lack of access to: markets (Powlson et al. 2016) and specialised CA equipment and the coded promotion of CA (Thierfelder et al. 2018) across varied farming systems which have high heterogeneity (Tittonell et al. 2007). This supports the fact that adoption of CA need to be contextualized.

Acknowledging that CA is not a "static technique" but has to be adjusted to meet the needs of the farmer, more research is required to understand barriers to CA adoption (Thierfelder et al. 2014). This is motivated by the several success stories of CA (Giller et al. 2015). The analytical framework in Figure 1.1 was used to represent factors that may affect adoption of CA at household, institutional and structural level.

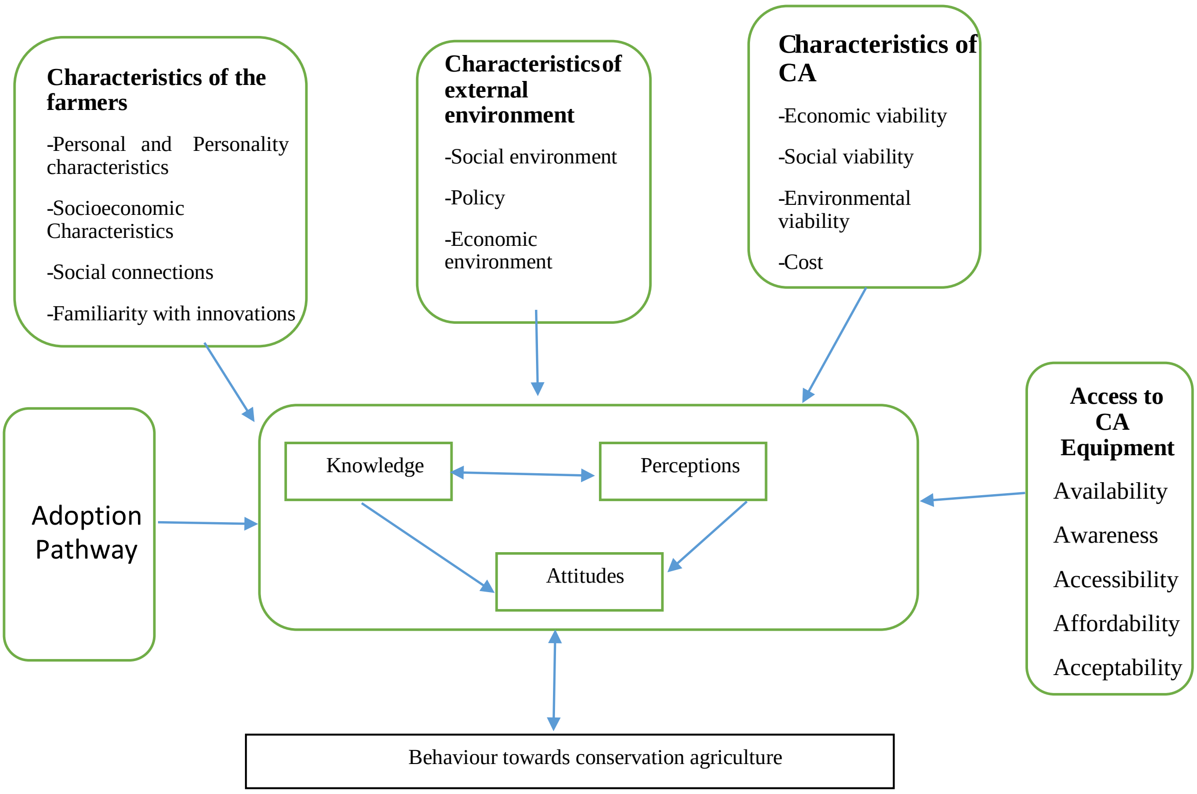

Figure 1. 1: Conceptual framework of the study centred on the role played by knowledge, attitudes and perceptions to understand adoption intention by smallholder farmers

(Modified from Meijer et al. 2015)

1.7 General methodology and study approach

The study employed a participatory research approach to collect data in Chivi, Murehwa and Mutoko districts in Zimbabwe. We purposeful selected these sites based on evidence of promotion of CA by different proponents since 2004 (Pedzisa 2016). Structured questionnaires, which were triangulated by focus group discussions and personal observations, were used to collect data in order to meet the requirements of the different objectives. Data was analysed using Statistical Package for Social Scientists (SPSS), Statistical Data Analysis Software (STATA), percentages, frequencies and logistic regressions.

1.8 Outline of the Thesis

The thesis is organized as follows:

Chapter 1: Background of the study; Chapter 2: Literature Review; Chapter 3: Behaviour of smallholder farmers towards adoption of CA; Chapter 4: Conservation Agriculture Adoption Pathways among smallholder farmers; Chapter 5: Access to CA equipment by smallholder farmers; Chapter 6: Access to markets by smallholder farmers and Chapter 7: Conclusion, recommendations and further research needs.

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CHAPTER 2: LITERATURE REVIEW

2.1 Definition of CA

CA has been defined as any farming system that involves simultaneous application of minimum soil tillage, diversified crop rotations and permanent soil cover (Mango et al. 2017). It's a suite of agricultural practices that aim to maximise agricultural output while protecting the environment and reducing production costs (Bhan and Behera 2014). It seeks to provide environmental services to the wider community through reduction in the use of fuels and pesticides. It also aims to reduce land degradation which is mainly associated with the plough. According to the FAO (2014), the practice is meant to sustainably achieve food and income security of household through judicious use of resources such as land, water and biological resources. CA has three key pillars which need to be applied simultaneously in order to derive full benefits (Giller et al. 2015). The three key pillars are: diversified crop rotations, minimum soil disturbance and permanent soil cover.

2.1.1 Diversified crop rotations

Crop rotations are important for biological diversity, soil nutrient cycling and pests and disease control (Giller et al. 2015). Where legumes are involved, this is important in enhancing soil nitrogen supply while reducing water pollution (Friedrich and Kassam 2009). In addition, legumes can act as good residues since they have low C/N ratio, besides their capacity to penetrate deeper soil layers which is important in nutrient cycling (Stagnari et al. 2017).

2.1.2 Minimum soil disturbance

Minimum soil disturbance is important for saving money, improving timeliness of planting operations (Biala and Terres 2007). It also improves soil structure, soil organic matter and improve water retention (Giller et al. 2015) Furthermore, minimum soil disturbance reduces weed proliferation (Muoni and Mhlanga 2014).

2.1.3 Use of crop residues or mulches as permanent soil cover

A permanent soil cover protects the soil from direct rain drop impact (Bhan and Behera 2014) and excessive heating. The soil cover also improves soil aggregation and water storage (Giller et al. 2015), which is a major advantage of CA in drier regions (Pittelkow et al. 2015).

2.2 Soil degradation in SSA

Soil degradation is of global concern because of its impacts on agricultural productivity and food security (Friedrich and Kassam 2011). The problem of soil degradation, which is exacerbated by climate change (Thornton et al. 2010) is extremely severe in SSA (Nkonya et al. 2016) where approximately 65 % of the arable land has experienced some form of degradation primarily due to poor soil fertility management practices (Zingore et al. 2015). Soil degradation is also linked to high prevalence of malnutrition in the region (Zingore et al. 2015). Given these challenges, there is need to focus on new sustainable agricultural technologies (Meijer et al. 2015) to produce adequate food from less land, using less labour and with reduced negative environmental impacts so that the future generations will have the same capacity (Campbell et al. 2014). Sustainable agricultural intensification is the only option to produce enough food for the SSA, a region which has not only the highest population growth rate in the world (PAI and AFIDEP 2010) but also has the highest number of malnourished people (OECD/FAO 2016).

CA is leading example of a sustainable agricultural practices adopted by FAO with a huge potential to address these agricultural production challenges (Kassam et al. 2015) especially amongst smallholder farming systems in Zimbabwe. However, CA only becomes very useful when adopted at household level (Oyulu 1983) or where there is farmer acceptance to implement it (Jack 2013).

2.3 Global adoption of CA

Globally, CA adoption has been motivated by the need to sustainably increase food and incomes, improve timeliness of operations, reduce labour costs, control land degradation and reduce the environmental footprint of agriculture (Farooq and Siddique 2014). CA has been promoted to increase agricultural productivity, improve climate resilience of agricultural systems while addressing land degradation, shortage of draft power and inputs in smallholder farming systems of SSA (Sims and Heney 2017).

The term CA was invented in the late 1990s just before the 1st CA World Congress that took place in Madrid, Spain (Giller et al. 2015). In 2015/16, global adoption was 180 million ha (Kassam et al. 2018). However, when it comes to CA adoption, Africa and Europe are viewed as "developing continents". In 2008/09, about 0.48 and 1.56 million ha of arable land were under CA in Africa and Europe respectively. By 2015/16, the area under CA had grown to 1.5 and 3.7 million ha for Africa and Europe respectively (Kassam et al. 2018). Although this corresponds to about 213 % increase over a period of eight years , the overall adoption remains very limited and piecemeal (Giller et al. 2011). Some scholars have expressed disappointment that while the people of Africa stand to be the highest beneficiaries of CA, in terms of hunger and poverty alleviation, it still a mystery why the adoption rates remain at less than 1 % of worldwide adoption considering the adoption data of 2015/2016 (African Conservation Network Tillage 2009).

In 2008/09, SSA had about 457 230 ha under CA (Kassam et al. 2015) which increased to 981 000 ha in 2011 (Friedrich et al. 2017) and then to 1 223 340 ha in 2013 (Kassam et al. 2015) representing an increase of 157 % over a period of five years from 2008 - 2013. However, compared to any other areas, CA adoption are awfully low despite the potential benefits in the region (Ndah et al. 2015). Several authors have suggested the urgent need for generating new knowledge on site specific facets of CA adoption in smallholder farming systems in SSA in order to improve adoption (Giller et al. 2009) Southern Africa on the other hand, has about 1 % of total arable area under CA (Hove et al. 2011). In fact smallholder farmers in SSA have been slow to take up CA (Fisher et al. 2018). This is despite the significant support from New Partnership for Africa´s Development (NEPAD), Alliance for a Green Revolution in Africa, governments and NGOs in SSA (Anderson and Giller 2012) and its huge potential contribution to economic growth, poverty alleviation (Jack 2013), restoration of degradation land (Lal 2015), food security and climate change adaptation and mitigation.

CA has been promoted to address productivity problems faced by smallholder farmers in Zimbabwe (Mazvimavi and Twomlow 2009). The United Kingdom Department for International Development (DFID) was at the forefront of supporting CA under the Protracted Relief Recovery Program (PRRP). Under this program, the beneficiaries who were mostly food insecure households received free inputs (especially fertilizers and seeds) and increased extension support. It is critical to mention that this program was purely coded and no farmer participated in the testing and designing of the technology but their challenges were rather presumed (Friedrich and Kassam 2009). That the practice (CA) is meant for poor households is actually not reflected in the sustained uptake of the practice and hence policy makers and academics have expressed concern at the low uptake rates (Mazvimavi and Nyamangara 2012).

By 2011, Zimbabwe had 139 000 ha under CA (based on FAO 2011estimates) (Friedrich et al. 2017) and is among a few African countries where adoption has been due to government support in addition to international donor agencies. However cases of abandonment of CA have also been reported after withdrawal of input support (Pedzisa et al. 2015a). There are however discrepancies in adoption rates reported by government, international development agencies such as the FAO (Kassam et al. 2018). Normally, the FAO reports adoption rates that are driven by projects (Andersson and Giller 2012). Additionally, some authors simply refer to no – till area as areas under CA (Giller et al. 2015). Worse still, some smallholder farmers in Zimbabwe only adopt some specific CA aspects (Pedzisa et al. 2015b).

According to Pedzisa (2016), they are eight standards practices that make up CA in Zimbabwe and these are: digging planting basins, winter weeding, application of mulch, localised manure application, basal fertiliser and top- dressing fertiliser application, early planting, timely weeding and judicious crop rotation which are being promoted to address agricultural productivity challenges faced by smallholder farmers (Mazvimavi and Twomlow 2009). However, majority of farmers only practice some components of CA (Giller et al. 2015). Of these practices, digging planting basins, manure application and timely post emergency weeding are practiced by majority of the smallholder farmers in Zimbabwe while crop rotation is receiving insignificant uptake (Pedzisa et al. 2015b). Although some authors have correctly argued that the full benefits of CA can be obtained when farmers use all the key pillars of CA simultaneously, for the purpose of our study, any farmer who uses any of the three key pillars or any of the standard practices suggested by (Pedzisa 2016) was assumed to be using CA. This was done in order to afford a broader analysis of the barriers to adoption.

2.4 Challenges to CA adoption

The adoption of agricultural technology is dependent among several social, economic, institutional (Teshome et al. 2012), intellectual and awareness, technical, enabling policy and infrastructural factors (Friedrich et al. 2009). Several studies have analysed the factors affecting conservation agriculture adoption. Anselmi et al. (2014) examined factors related to adoption of precision agriculture in Southern Brazil (Anselmi et al. 2014). The found the relative advantage to be the most significant variable. In another study, Ntshangase, Muroyiwa, and Sibanda (2018), studied factors influencing no till adoption in small scale farmers in Zashuke, KwaZulu – Natal, South Africa. Their results indcate that extension visits, age, education and positive perception of farmers had significance influence on adoption of no till while an increase in land size negatively **a**ffected adoption of no till. In their study on the factors of CA adoption among Zambia smallholder farmers, Mbata et al. (2016), found out that social and cultural factors, access to CA machinery that reduces labour and access to inputs and market influence adoption of CA. Obayelu et al. (2017) did a literature review of factors affecting adoption of technology and found out that farmer characteristics, social networks, economic, capital, farm size and access to information were the main variables. Tam et al. (2014) found out that proponents of new innovations need to ensure that the 4As of adoption are always in place to ensure that barriers to adoption are addressed. The 4As are awareness, advantage, affordability and accessibility. In their findings Tam et al. (2014) emphasized the need to invest in early adopters as these act as role models in raising awareness to would be adopters. In terms of advantage, they indicate that financial benefit is the major driving factor of adoption. With regards to affordability, they emphasise that the products must be within the reach of the farmers and must also have affordable financing options. Lastly, Tam et al. (2014) emphasized the need to consider the access dimension which is critical given that rural infrastructure in SSA is poorly developed. Poor infrastructure has been cited as a hindrance to development in SSA. Some authors have pointed out that most rural roads in SSA are in a bad state of repair Kiprono and Matsumoto (2014) With poor road networks, inputs become more expensive and markets for products become more inaccessible (Kiprono and Matsumoto 2014). These might be a hindrance to access to equipment and markets thereby reducing profitability of innovations.

Sadati et al. (2010) investigated the determinants of farmers' attitude towards sustainable agriculture in Iran and found that age, experience in agriculture, family and farm size are negatively related to attitude towards sustainable agriculture, while those with off farm income, more knowledge about sustainable agriculture, contacts with extension agents and job satisfaction have a positive attitude towards sustainable agriculture.

On the other hand, Meijer et al. (2015), studied how the uptake of agricultural innovations in SSA may be affected by the knowledge attitudes and perceptions. Their results indicate that farmers' decision on adoption is affected by knowledge, attitude and perception which are however dependent on the socio economic variables.

Ndah et al. (2014) assessed the potential for adoption of CA in SSA using case studies from Burkina Faso, Malawi, Zambia and Zimbabwe. Their results indicate that sustained adoption of CA was constrained by competition for residue between CA and livestock particularly for Burkina Faso, lack of markets for both inputs and markets especially for Zimbabwe and Burkina Faso, absence of recognised CA networks in Burkina Faso, nature of communication networks used in CA dissemination and availability of quality control and the technical nature of CA in the case of Zimbabwe, complication of the CA package and low acceptance of CA by the younger generation in Zambia and Zimbabwe, the absence of enabling policy environment at the village level in Zambia and access and ownership of land in Zambia and Malawi. The importance of communication networks is further buttressed by Salvia et al. (2018), who indicate that researchers need to consult with stakeholders (farmers) so that the information they provide is in sync with their challenges. Closing the communication gap between farmer and scientist (Odendo et al. 2006) would enhance adoption of yield enhancing agricultural practices whose adoption are very low (Mashavave et al. 2013). Additionally, in certain circumstances, there might be need to consult with opinion leaders who are better placed to influence the behaviour of the proximal neighbours (Geeson et al. 2015) in addition to provide a portfolio of technologies from which farmers can make choices rather than being rigid in nature.

Thierfelder et al. (2015) reviewed literature on state of knowledge about CA benefits and the constraints faced by smallholder farmers in southern Africa. Their review indicate that farmers prefer to feed crop residue to livestock, which would in turn provide farmers with manure and draught power. If manures are used prudently, they could enhance yields in nutrient depleted soils in most communal areas of Zimbabwe (Rusinamhodzi et al. 2013). On the other hand, some government still support monocropping as is this case with Malawi where farmers are provided with subsidized inputs such as seeds, fertilizers and agricultural chemicals thereby promoting the farmers to use a greater portion of the land for the supported crop (Ngwira et al. 2012). In countries such as Zambia, where potential for rotation exist, several challenges still militates against adhering to full rotation. These range from absence of lucrative markets for legumes, lack of interest by seed houses to produce legume seeds that have no demand (Thierfelder et al. 2015), lack of appropriate legume germplasm to phosphorus depleted soils (Graham and Vance 2003). Several authors have identified changes in weed dynamics (Mtambanengwe et al. 2015) and weeding density (Baker et al. 2018) under CA. For example, annual and perennial monocotyledons and dicotyledons weeds flourish differently under conditions of minimum soil disturbance and residue retention (Mashingaidze et al. 2012). Although mulching supresses annual weeds, perennial weeds tend to be problematic under no till (Mashingaidze et al. 2012).

With regards to labour issues, certain components of CA such the manual digging of planting basins are considered labour intensive compared to conventional tillage. In this case, mechanized CA could enable farmers to take advantage of appropriate planting dates thereby taking maximum advantage of first rains (Nyagumbo et al. 2017). The challenges discussed herein are compounded by lack of access to CA machinery (Twomlow et al. 2008), herbicides and pesticides particularly in southern Africa which are all linked to imperfect markets and socio economic constraints.

The importance of social network on technology adoption pathway has been studied by several authors. Wossen et al. (2013) investigated the influence of social network on the adoption of natural resources management in Ethiopia. They found that the social network size is important in enhancing adoption of sustainable natural resources management strategies implying the copying effect/imitation adoption pathway. This finding is further supported by earlier work by Kong (2011) who argued that the social network reduces information asymmetry and cost of transactions and negotiating leverage. Murendo et al. (2018) found out that the adoption of mobile phone technology in Mukono and Kasese districts in Uganda is positively influenced by the social network size. In their findings, (Wossen et al. 2013) also argue that knowledge acquired through observations is stronger than learning by doing. On the other hand, (Matuschke and Qaim 2009) investigated the influence of social network on the selection of hybrid seed in India and found that the social network are critical in the early stages of adoption. However, another interesting observation from this study is that information exchange follows a homophilous as opposed to heterophilous patterns in most village settings. In another study on the role of information flows and social externalities in a banana growing village in Tanzania, (van den Broeck and Dercon 2011) found out that majority of farmers depend on their social networks for agricultural information and less on external sources. (Banerjee et al. 2013) investigate the diffusion of microfinance information in India and found that even those who are not taking part in a new product can also pass on information to their neighbours even if chances are higher that product adopters are responsible for passing information to their proximal neighbours. In a related study, (Bandiera et al. 2006) investigated the role of social network in technology adoption in northern Mozambique. They found that decisions on adoption are more associated with friends and neighbours as opposed to religious networks. On the other hand, farmers make use of their local social connections to make informed decisions and manage technology associated threats. However, for some innovations where incentives are involved, adoption might be “forced” for example Operation Joseph in the case of CA adoption in Zimbabwe. From this discussion, it can be argued that there are three distinct pathways of technology adoption: adoption could be through individual learning about a new technology (Knowledge pathway), adoption through association (identification pathway) and adoption and through compliance (compliance pathway).

Several scholars have investigated the role of mechanization in technology adoption. Bahattin (2013) investigated agricultural mechanization in Turkey and found that challenges with mechanization range from lack of awareness on the use and maintenance of equipment, ancient machines to purchase of unnecessary farm machinery. The need for agricultural mechanization in the promotion of agricultural intensification is recognised by the Comprehensive African Agricultural Developmental Programme (CAADP), policy makers and academics. However, SSA is largely not mechanized (Silver et al. 2016) and the level of mechanization is on the decline (Pingali 2007). The low levels of mechanization has been attributed to supply bottlenecks such as: lack of spare parts, skilled personnel to offer after sale services such as calibration and repairs and demand constraints such like affordability and access to markets (Pingali 2007).

Farm viability is the major driver of adoption of mechanization in Punjab state in India (Singh et al. 2016). These findings are also corroborated by motivation for mechanization in Southern Nigeria (Takeshima et al. 2013). On the other hand, mechanization was found to be slightly related to market access (Cossar 2016) as farmers are not prepared to increase productivity without assurance of markets for the products (Heisey 1996). Farmers located in areas with shorter growing seasons are more likely to be mechanized in order to ensure timeliness of operations especially planting (Cossar 2016). On the other hand farmers situated far away from urban centres are unlikely to use machinery especially if they rely on hiring services as owners of machinery prefer to services accessible areas (Cossar 2016). The similar author also found out that agroecology plays a significant role in mechanization. There is a lot of work that has been done to develop CA equipment for east and southern Africa including Zimbabwe (Silver et al. 2016). Notable CA equipment designed in Africa include animal drawn rippers, direct seeders and two-wheel tractor – drawn strip tillers and seed drills. On the other hand, some of the machinery developed in Africa include the Palabana animal drawn rippers that was developed in Zimbabwe (Johansen et al. 2012). Increased access to mechanization may increase agricultural transformation and adoption of sustainable agricultural practices such as CA in Africa. However, smallholder farmers may have low access to CA equipment due to limited availability, lack of awareness, high costs, lack of accessibility and poor acceptance.

2.5 Conclusion

Several studies have studied the barriers to adoption of conservation agriculture. The literature review suggest that factors that affect technology adoption can be grouped into social, economic, institutional and policy. However studies of CA adoption reveal that smallholder farmers do not adopt the full package of CA. Additionally, some of the adoption figures are guest estimates. Lastly, some adoption figures are project specific where farmers are incentivised to adopt CA.

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CHAPTER 3: Behaviour of smallholder farmers towards adoption of Conservation Agriculture in Zimbabwe [1]

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 Chivi, Murehwa and Mutoko districts, 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 districts, 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 ($R_s = 0.306$, $P < 0.05$) and knowledge and adoption ($R_s = 0.484$, $P < 0.05$) but a strong and significant correlation between perception and adoption ($R_s = 0.808$, $P < 0.05$). This paper confirms that

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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

3.1 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).

The dust bowls that hit in the Great Plains in the USA in the 1930s following prolonged droughts triggered the development of reduce tillage systems (Kassam *et al.*, 2014a). However, its expansion in the 1980s and 1990s in America and Australia was facilitated by multiple factors namely a) availability of effective herbicides (LeBaron *et al.*, 2008) to control weeds, b) invention of no till planters that facilitated direct seeding into mulch, c) government policy incentives that heavily supported transition to reduced tillage practices (Fuglie & Kascak, 2001) and d) the advent of herbicide resistant, genetically modified crops which enabled farmers to use post – emergence herbicides (National Research Council, 2010).

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 (Thierfelder *et al.*, 2014; Thierfelder *et al.*, 2015a; 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 herbicides 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 (Bhan & Behera, 2014; 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 (Johansen *et al.*, 2012; Brown *et al.*, 2018a; 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.

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).

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).

Therefore the specific objectives of this study were:

1) To determine the socio – economic characteristics of the respondents

2) To assess the level of knowledge of the respondents on CA and identify socio-economic attributes that affect the respondents' knowledge

3) To assess the level of perception of the respondents towards CA and identify the related socio - economic attributes that affect respondents' perceptions

4) To correlate knowledge and perceptions, knowledge and adoption and perception and adoption.

3.2 Materials and Methods

3.2.1 Study area

The study was carried out in three districts of Zimbabwe. Chivi district is located in the southern part of Zimbabwe. The district represents a typically low areas under agro –ecological zone V. The soils in the district are sandy soils derived from granite. These soils have very low inherent fertility (Mapanda & Mavengahama, 2011). Rainfall is the major factor limiting crop production in the area (Mutekwa & Kusangaya, 2006). Murehwa 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). On the other hand, Mutoko district is located in the northern eastern side of Zimbabwe. The district is in agro ecological zone IV (Otzen, 1995), and receives between 450 – 600 mm per season. However, the rainfall is characterized by mid-season dry, spells (Bhatasara, 2015). The major soils granitic derived sandy soils although dolerites are found in some in some locations (Chikuvire & Mpepereki, 2012). The study area is shown in Figure 3.1.

Figure 3. 1: Location of the study sites in Zimbabwe

3.2.2 Sampling Techniques

A multi stage sampling technique was used for sampling starting with purposeful selection of three AEZ followed by purposeful selection of three districts in each AEZ. The third stage involved random selection of three wards in each 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.

3.2.3 Measurement of variables and data analysis

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).

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. We also performed a pair-wise correlation analysis in order to establish the relationship between knowledge and perception, knowledge and adoption and perception and adoption.

Objectives 2 and 3 were analysed using percentages, means, a 3 – point Likert decision rule model and multinomial regression, objective 1 was analysed using percentages and frequencies and objective 4 was analysed using correlations.

According to the Likert Model decision rule by Williams (2015), ≥ 2.0 is accepted while < 2.0 is rejected.

3.2.3 Model accuracy

Cronbach's alpha (α) was used to test the reliability of the knowledge and perception statements, the Average Variance extracted (AVE) to determine the inter item correlation and the Index of Measurement Error (IME) to assess the error variance.

3.3 Results

3.3.1 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 3.1).

Table 3. 1: Selected demographic attributes of respondents (n-=349)

Socio economic attributes	Frequency	%
Sex		
Males	164	47
Females	185	53
Age (years)		
<21	1	0.3
21 – 30	21	6
31- 40	67	19.2
41- 50	111	31.8
>50	149	42.7
Marital status		
Married	251	71.9
Single	98	28.1
Education level		
No formal education	103	29.5
Primary	150	43.0
Secondary	93	26.6
Tertiary	3	0.9
Formal Agricultural Training		
None	323	92.6
Certificate and above	26	7.4
Major source of income		
Agriculture	292	83.7
Remittances	44	12.6
Off farm Employment	13	3.7
Years of practicing CA		
0	120	34.4
<5	108	30.9
5 – 10	94	26.9
>10	27	7.7

3.3.2 Respondents' knowledge on CA

Model accuracy

The Cronbach's alpha for the 11 statements used to assess respondents' knowledge was 0.947 which exceeded the threshold value of 0.7 showing very good reliability. The Average variance extracted (AVE) for the knowledge statements was of 0.564 which exceeded the threshold of 0.5 thereby showing very good internal consistency. The Index of Measurement Error (IME) of 0.103 indicates a low error variance. All the 11 statements loaded above 0.5 threshold (Table

3.2). On the other hand, the Cronbach’s alpha for the three perception statements was 0.946 which exceeded the threshold value of 0.7 showing good reliability.

The questionnaire sought to investigate the respondents’ level of knowledge on the social environmental and economic viability of CA. The mean value of the social viability variable range from 2.17 to 2.42, 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 0.043 to 0.049, indicate a fair range of the responses**.** On the other hand, the mean values of the environmental viability statements range from 2.43 to 2.64, reflecting a high degree of agreement from the respondents to the variable. The participants agreed with all the statements in this variable. The standard error values, which range from 0.037 to 0.043 indicate a fair range of the responses. The last variable is the economic viability variable with mean values ranging from 2.29 to 2.58 reflecting a high degree of agreement from the respondents to this variable. The standard error values, which range from 0.039 to 0.048 indicate that there seems to be a fair range of the responses. The overall knowledge score of the social, environmental economic viability of CA is a score of 2.46 and standard error; 0.042 as shown in Table 3.2.

Table 3. 2: Knowledge, model reliability and mean score of farmers' knowledge about CA

ITEM	MEAN	SE	DECISION	FACTOR LOADING
Social viability of CA				
Performance improves over time	2.42	0.045	Accepted	0.619
Results in observable yield increments	2.39	0.043	Accepted	0.685
Easy to practice	2.17	0.049	Accepted	0.593
Overall	**2.33**	**0.046**	**Accepted**	
Environmental viability of CA				
Reduces soil erosion	2.64	0.037	Accepted	0.821
Can restore degraded lands	2.46	0.042	Accepted	0.721
Environmentally friendly	2.60	0.037	Accepted	0.841
Controls pests and diseases	2.43	0.043	Accepted	0.723
Overall	**2.53**	**0.040**	**Accepted**	
Economic viability of CA				
Reduces costs of labour	2.29	0.048	Accepted	0.708
Reduces cost of inputs	2.51	0.039	Accepted	0.819
Improves yields	2.58	0.041	Accepted	0.837
Improves income	2.54	0.041	Accepted	0.838
Overall	**2.48**	**0.042**	**Accepted**	
Overall Knowledge score	**2.46**	**0.043**	**Accepted**	

In addition to assessing the level of knowledge of the respondents on CA, we also assessed the socio-economic determinants of the knowledge variable using a multinomial regression model. Our model was fitted for all three districts in our study. 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 3.4).

3.3.2.1 Classification of respondents based on CA knowledge

Table 3.3 shows that 62.5 % of the respondents had high CA knowledge levels.

Table 3. 3: Classification of farmers on knowledge level of CA

Knowledge category	Frequency	Percentage	Mean	SE
High	218	62.5		
Medium	88	25.2	2.46	0.043
Low	43	12.3		

Table 3. 4: Knowledge level on CA multinomial regression model

Variable	Chi-Square	P value
Age	16.072	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 Ch^{i2} 284.125; Pseudo R^2 0.453 Log Likelihood -158.6825; Note: * significant at 5 % probability level

3.3.3 Farmers' perception towards CA

Model accuracy

The AVE for the perception statements was 0.791 which exceeded the threshold of 0.5 thereby displaying good internal consistency. The Index of Measurement Error (IME) of 0.105 meant a very small error variance. All the 3 statements loaded above the acceptable 0.5 threshold (Table 3.2).

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 3.5). According to the results, the perception of 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 3.6 which shows that majority of the non-adopters had indifferent perceptions towards CA.

Table 3. 5: Perception, model reliability and mean score of non-adopters about CA

Item	Mean	SE	Decision Rule	Factor loading
Lack of equipment	2.12	0.031	Accepted	0.835
Decline in yields	2.10	0.031	Accepted	0.944
May lead to serious problems	2.10	0.030	Accepted	0.885
Overall perception	**2.11**	0.031		

AVE = 0.791; α = 0.946 and IME = 0.105

3.3.3.1 Classification of respondents' based on perception towards CA

Table 3. 6: Classification of non-adopters based on their perception towards CA.

Perception category	Frequency	Percentage	Mean	SE
High interest	41	11.7		
No interest	232	66.5	1.55	0.70
Low interest	76	21.8		

In addition to assessing the perception of the respondents towards CA, we also assessed the socio-economic determinants of the perception construct using a multinomial regression model. Our model was fitted for all three districts.

3.3.3.2 Determinants of respondents' perception on CA

The log likelihood Ratio Chi ^{2} was 289.602 and the log likelihood was -140.584 (Table 3.7) 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 3.7).

Table 3. 7: 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 to conferences	6.252	0.004*
Years of practicing CA	3.342	0.032*

Likelihood Ratio Ch^{i2} 289.602

Pseudo R^2 0.485

Log Likelihood -140.584

Note: * significant at 5 % probability level.

3.3.4 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 ($R_s = 0.808$, $P < 0.05$).

3.4 Discussion

3.4.1 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.

3.4.2 Respondent's knowledge on viability of CA

Model accuracy

The model displayed a very high reliability α values > 0.7 which is acceptable (Tavakol & Dennick, 2011). Additionally, internal consistency was good: AVE values > 0.5 (Hung *et al.*, 2009). Finally, IME was close to 0.00 in all cases, which is acceptable (Tavakol & Dennick, 2011). Details are shown in Tables 3.2.

The respondents indicated that CA is socially, environmentally and economically viable with mean scores of respectively 2.33; 2.53 and 2.48 respectively giving a total knowledge score of 2.46 (Table 3.2). This analysis, which looks at the systems approach in sharp contrast to the agronomic approach is important in identifying technologies which are acceptable to farmers in different situations (Giller *et al.,* 2015). In the following section each of these issues is analysed in detail.

3.4.2.1 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 3.2. 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 3.2. 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 3.2. 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.

3.4.2.2 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 3.2. 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 3.2. 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 3.2. 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 3.2. 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.

3.4.2.3 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 3.2. 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 3.2. 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 yields

The respondents indicated that CA leads to improved yields with a mean score of 2.58 (standard error = 0.041) as shown in Table 3.2. 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 3.2.

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).

3.4.3 Factors determining respondents' knowledge on Conservation Agriculture

3.4.3.1 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.

3.4.3.2 Gender

Our results 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.

3.4.3.3 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).

3.4.4.4 Attendance to demonstration sites

Our 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)

3.4.4 The respondents' perceptions towards CA

Model accuracy

The model was high reliability (α values > 0.7), which is acceptable (Tavakol & Dennick, 2011). In addition, the internal consistency was good with AVE values > 0.5 (Hung *et al.*, 2009). Lastly, IME was close to 0.00, which is acceptable (Tavakol & Dennick, 2011) as shown in Tables 3.5.

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.

3.4.4.1 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 the three districts have to prepare the basins every season since the granitic derived sand soils are dominant soil types in all the three districts. 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.

3.4.4.2 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 paper.

3.4.4.3 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 implication.

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.

3.4.5 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 3.7). Majority of these are the same factors which had a significantly influence on the level of knowledge of the farmers about CA (Table 3.4). 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.

3.4.5.1 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.

3.4.5.2 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 the three districts may have shaped the initial perception of the farmers. In Mutoko and Murehwa, 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. However, in Chivi, CA was part of the Department for International Development (DFID) Protracted Relief Programme (PRP) and CARE undertaking field work while the International Crop Research Institute for Semi- Arid Tropics (ICRISAT) provided the technical support. The PRP targeted food insecure and vulnerable, particularly female headed households. 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 our paper 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.

3.4.6 Correlation between Knowledge and Perception; Knowledge and Adoption and Perception and Adoption

Our results 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 ($R_s < 0.5$) 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.

3.5 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 paper 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 4: Conservation Agriculture Adoption Pathways among smallholder farmers in Zimbabwe [2]

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 Chivi, Murehwa and Mutoko, 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.

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4.1 Introduction

Sustainable Agriculture in the form of conservation agriculture is an integral part of several global, regional and national initiatives which are meant to balance the trilemma challenges of sustainably improving food security, adapting to climate change and reducing greenhouse gas emissions, particularly from agriculture. These initiatives include the United Nations Conventions (Agenda 2021, Agenda 2030 for Sustainable Development, the Paris Agreement and the Intended Nationally Determined Contributions) and other regional initiatives such as the Feed for Africa Program, New Partnerships for Africa Development, Comprehensive Africa Agriculture Development Program and the Malabo Declaration.

Agenda 2021 seeks to among other things reduce poverty through promotion of sustainable agriculture and rural development, reducing land degradation, conservation of biological diversity, transfer of environmentally friendly practices and harnessing science for sustainable development. Sustainable agriculture is at the core of the 2030 Agenda (FAO 2008), specifically Sustainable Development Goal 2 on hunger, food security, nutrition and promotion of sustainable agriculture, Sustainable Development Goal 6 on sustainable management of water resources, Sustainable Development Goal 12 on responsible production and consumption patterns, Sustainable Development Goal 13 on combating climate change and its impacts, Sustainable Development Goal 14 on conserving marine resources, Sustainable Development Goal 15 on sustainable use of terrestrial ecosystems, reversing land degradation and loss of biodiversity. In addition sustainable agriculture contributes to Sustainable Development Goal 1 (poverty reduction) through empowerment of disadvantaged groups, promotion of market access and value chains. On the other hand, the Feed for Africa initiative seeks to transform the agriculture sector through technology dissemination, mechanization, increased funding in climate resilience and climate- smart technologies for improve food security, elimination of hunger and malnutrition and ending poverty. The New Partnerships for Africa Development, which is paying strong attention towards sustainable agriculture (Friedrich et al. 2017), has since incorporated conservation agriculture as a strategic component of its agricultural development framework (Kassam, Friedrich, Shaxson, & Bartz, 2014). The Intended Nationally Determined Contributions recognize climate change as a threat to sustainable agriculture while at the same time places agriculture as a possible solution to the climate change problem (FAO 2016). Also the landmark Paris Agreement recognizes the importance of climate – agriculture and food systems interconnection for sustainable economic growth. The Comprehensive Africa Agriculture Development Program recognizes that targeting at least 10 percent of budgetary allocation to the agriculture sector is important for sustainable agricultural growth and development (MAMID 2012). Under Malabo Declaration, the African Heads of State have also committed themselves to ensuring that agricultural systems are resilient to the risks posed by climate variability and change (Ababio 2017). Globally, agricultural production systems need to sustainably increase yields to meet the increased demand for food, feed and biofuels without increasing the environmental foot print of agriculture. They also need to be more efficient, resilient to the vagaries of climate change and provide ecosystem services. Additionally, agricultural production systems need to change from being drivers of land degradation and biodiversity loss (IAASTD, 2009) so that they become agents of land restoration and increased biological diversity. This requires the widespread adoption of sustainable agricultural practices such as conservation agriculture.

There is enormous policy and institutional support being paid to promotion of conservation agriculture by the Government of Zimbabwe, national research and extension establishments, international developmental aid agencies, research institutions and relief organizations (Kassam et al. 2014a). In Zimbabwe, conservation agriculture can address agricultural productivity challenges such as high rainfall variability (Rurinda et al. 2014), high costs of inputs (Anseeuw and Saruchera 2012), shortage of draft power (Makuvaro et al. 2017) and labour (Munhande et al. 2013) which are prevalent among the smallholder farmers (Nyagumbo et al. 2017). These challenges are further exacerbated by land degradation (Mapanda and Mavengahama 2011) as a result of poor soil management practices (Zingore et al. 2015) including soil nutrient mining (Henao & Baanante, 2006), poverty (Mapfumo et al. 2013), deteriorating social safety nets (Rurinda et al. 2014) and lately weakening of the Bond note thereby creating a three tier pricing system for commodities.

However, despite several years of research and promotion of conservation agriculture as a remedy for non-viable agricultural farming systems and decline in soil fertility in Zimbabwe, the adoption rates remain very limited (Zira et al. 2013. Farmers adopt new technologies through different pathways. In Nigeria, farmers adopt certain practices just because those in similar circumstances would have adopted (Adjognon and Liverpool-tasie, 2015). In Ethiopia, adoption of natural resources management practices is based on the decision by friends, relatives and neighbors (Wossen et al. 2013). Langyintuo and Mekuria (2005) emphasized the need to consider spatial dependence on technology adoption in Mozambique. The behavior of others is critical where the cost and benefits realized from the technology are a function of number of people who have adopted the technology especially where farmers learn from network members (Bandiera & Rasul, 2006). The same authors also identified peer pressure and imitation behavior as some of the reasons for adoption and this "herd behavior" is well known which may lead people to adoption of inferior technologies (Sun 2009). Additionally, networking may create room for conditional support from members in a group. This applies to conservation agriculture adoption where farmers may need to share labor, equipment and ideas (Giller et al., 2009). Imitation is also applicable where there is need to reduce financial constraints and transaction costs through group bargaining (Willy & Holm-Müller, 2013). Some farmers adopt conservation agriculture in Zimbabwe in return for input support (Mazvimavi, 2011). However, there is also evidence of voluntary uptake of conservation agriculture after a period of learning from neighbors and adoption by vulnerable households with no external input support (Mazvimavi, 2011). Therefore, it can be argued that technology adoption pathways can be categorized into the knowledge, compliance and identification.

4.1.1 Knowledge pathway

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

4.1.2 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.

4.1.3 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 paper 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.

4.2 Materials and methods

4.2.1 Study areas

The study was conducted across three districts in Chivi, Murehwa and Mutoko in agro-ecological zones V, II and IV respectively. A total of 360 smallholder farmers participated in the survey between March and October 2017. 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. Chivi district is located in Masvingo Province, south –central Zimbabwe. The district is characterised by low, erratic rainfall and frequent dry spells. The soils in the area have low inherent fertility which limits agricultural productivity. Murehwa is located in Mashonaland East Province, north –east Zimbabwe. Rainfall in the is moderately well distributed (Masvaya et al. 2010). Granitic derived sandy soils with low inherent fertility are the dominant soils in the district (Nyamapfene 1991). Mutoko district is located Mashonaland East Province in north - east Zimbabwe. Fersiallitic granitic derived soils are the dominant soils in the area (Nyamapfene 1991). Rainfall in the district is characterised by high spatial-temporal variability.

4.2.2 Data collection

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. We had 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.

4.2.3 Model reliability and validity

The questionnaire was pretested to check model reliability and validity in Chivi District. This involved distributing the questionnaire to 15 participants in one of the targeted wards. We conducted the Cronbach's Alpha, Average Variance Extracted and inter item correlations in order to explore the reliability of our model. More Specifically, Cronbach's Alpha was conducted to assess the reliability of the adoption pathway variables while the average variance extracted and inter item correlations were used for assessment of discriminant validity. As a rule of thumb, acceptable values for Cronbach's Alpha and average variance extracted are $\geq$ 0.7 and $\geq$ 0.5 respectively (Elkaseh et al. 2016). On the other hand, inter item correlations $\geq$ 0.85 indicate poor discriminant validity (Park 2009).

4.2.4 Data Analysis

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.

4.2.4.1 Multinomial logistic regression

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.

4.2.4.2 Decision Rule

Likert Model

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

Where,

X = weighted mean (mean score)

X = Likert value

$\sum$ = summation n = total respondents / sample size)

4.3 Results

4.3.1 Demographic data

The majority (53 %) of the respondents completing the questionnaire were female, married and had received some form of formal education (Table 4.1).

Table 4. 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), (= <5), (3 = 5 - 10), 4 = >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	0.37	0	1

4.3.1.2 Age distribution of the farmers

The age distribution of the respondents is indicated in Table 4.2

Table 4. 2: Age distribution of the respondents

Age group	Frequency	Percentages
<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 4.1).

4.3.2 Measurement model reliability and validity

The factor loadings, Cronbach's Alpha and average variance extracted are presented in Table 4.3. Our composite reliability (α) values ranges from 0.82 – 0.87 while the average variance extracted range from 0.67 – 0.75 (Table 4.3). Accordingly, all our measures fulfil the recommended thresholds revealing strong internal consistency and accuracy.

Table 4. 3: Summary of means, construct factor loadings and reliabilities

Construct	***Statement***	***Mean***	***loadings***	***α/AVE***
	I adopted CA in return for seed support.	2.03	0.83	
Compliance	I adopted CA to get improved extension support.	2.1	0.85	0.82/ 0.67
	I adopted CA to get fertilizer from donors.	1.94	0.78	
(Overall)		**2.02**		
	I adopted CA because all my peers are using it.		0.88	
Identification	I wanted the support of my neighbours in implementing CA.		0.92	0.86/ 0.72
	I adopted CA so as to fit in my society.		0.74	
(Overall)		**1.82**		
Knowledge	I adopted CA after learning about its benefits from peers	2.16	0.91	
	I adopted CA after learning about its benefits from extension agents.	2.09	0.87	0.87/ 0.75
	I adopted CA after observing its benefits from others using it.	2.15	0.76	
(Overall)		**2.13**		

We also conducted some inter item correlations whose results are indicated in Table 4.4.

Table 4. 4: Correlations between variables

Construct	Knowledge	Compliance	Identification
Knowledge	1.000	0.598	0.420
Compliance	0.598	1.000	0.547
Identification	0.420	0.547	1.000

4.3.3 Adoption Pathways

The hypotheses were confirmed by examining the value of the mean of each construct using the Likert model decision rule for a 3 point Likert scale. Therefore, the adoption of conservation agriculture was predicted by knowledge (mean score of 2.13, standard error of 0.043) and compliance (mean 2.02, standard error 0.043) as shown in (Table 4.5). According to our results, the knowledge and compliance were the significant adoption pathways.

Table 4. 5: Summary statistics of the hypothesis

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

4.3.3.1 Socio demographic factor affecting significant adoption pathways

Table 4.6 shows the regression results of the knowledge pathway to adoption while Table 4.7shows 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 4. 6: 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	11.120	0.004*
Master Farmer Training	1.632	0.442
Experience in Agriculture	10.012	0.024*
Demo Visits	6.078	0.048*
Attendance to conferences	3.936	0.140
Agricultural Cooperatives	14.704	0.23

Likelihood Ratio Ch^{i2} 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 4.7).

Table 4. 7: 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
Adult members	3.628	0.459
Education Level	32.76	0.365
Formal Agricultural Training	3.067	0.216
Master Farmer Training	2.112	0.348
Experience in Agriculture	14.76	0.322
Labour Source	1.019	0.601
Demo Visits	6.416	0.400
Attendance to shows	3.671	0.160

Likelihood Ratio Ch^{i2} 132.663; Pseudo R^2 0.173;

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

4.4 Discussion

4.4.1 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).

4.4.2 Measurement model reliability

Our measurement model was both reliable and valid considering Cronbach's Alpha value were > 0.7 (Elkaseh et al. 2016). On the other hand, the average variance extracted values are >0.5 implying strong inter item correlations (Park 2009). Additionally, discriminant validity is further met as inter item correlations do not exceed 0.85 (Elkaseh et al. 2016).

4.4.3 Adoption Pathways

4.4.3.1 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.

4.4.3.2 Compliance adoption pathway

The results show that farmers in the three districts 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 all the three districts. 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 labor 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).

4.5 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 5: Access to Conservation Agriculture equipment by smallholder farmers [3]

Abstract

Conservation agricultural is labour intensive. This may limit its adoption by majority of smallholder farmers who are constrained by labour. Therefore, the objective of this study was to evaluate access to conservation agriculture by smallholder farmers in Chivi, Murehwa and Mutoko districts located in different ago – ecological zones of Zimbabwe. Qualitative and quantitative data was collected through a household questionnaire, which was triangulated through focus group discussions, key informant interviews and personal observations. The mean access score (1.72), defined by affordability, availability, acceptability, accessibility and awareness was low. The significant socio – economic variables of access were age, level of formal education, experience with agriculture and area under conservation agriculture ($P < .05$) while the significant non – socio – economic access factors were affordability, availability, acceptability, accessibility. There is need to improve affordability; availability, acceptability and accessibility of the conservation agriculture equipment to increase adoption of conservation agriculture by smallholder farmers.

Key words: affordability, availability, accessibility, acceptability, awareness, Zimbabwe.

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5.1 Introduction

Access to agricultural mechanization is critical in sustainably transforming Africa's agriculture to meet the targeted sustainable economic growth, poverty reduction (IFPRI 2016) and food security objectives. Both the African Union Commission (AUC) and the Food and Agricultural Organization (FAO) consider the mechanization of African agriculture as a prerequisite for the realisation of the African Union's Agenda 2063 (Müller *et al*. 2017), the Malabo Declaration (African Union 2014) and Sustainable Development Goal (SDG) 2 (FAO and AUC 2018). At the 25th African Union Summit of Heads of States and Governments held in South Africa in 2015, several women groups pushed for strong support towards agricultural mechanization in Africa, with the former AUC Chairperson Dr. Nkosazana Dlamini Zuma (2012-2017) strongly pushing to "confine the hand - hoe to the museum" in order to free the African smallholder farmer from hard labour (FAO and AUC 2018), in line with the declaration of the Africa Union "Agenda 2063: The Africa We Want" (AUC 2015)

In line with the African Union's Agenda 2063, the Malabo Declaration and SDG 2, agricultural mechanization is critical to doubling agricultural productivity; ending hunger and malnutrition; ensuring agriculture contributes to national food security and economic transformation; improving the resilience of livelihoods and agricultural production systems to climate change and poverty reduction. However achieving the above targets is becoming increasingly difficult given the negative implications of climate change and extreme weather events on agriculture (Katrin and Gordon 2016), in the absence of climate – proofing strategies.

Climate Smart Agriculture practices, defined as any agricultural practices that can assist farmers to adapt and mitigate the negative impacts of climate change as well as improving food and income security (Thierfelder *et al*. 2017) are critical for climate – proofing the Malabo Declaration, Agenda 2063 and the SDG 2 (Katrin and Gordon 2016). Conservation Agriculture

(CA) is widely regarded as a promising climate smart technology for southern Africa (FAO 2013).

However, the full benefits of CA are realised when the principles of CA are applied simultaneously (Baudron *et al*. 2007; Giller et al. 2009). Nonetheless, farmers in southern Africa rarely adopt the complete package (Mazvimavi *et al*. 2008). At the same time, simultaneous application of the principles require farmers to be mechanized since reduced tillage, direct planting, weeding and management of crop residues may require some specialised equipment (FAO 2009). Cases of CA abandonment (Pedzisa *et al*. 2015a) and partial adoption (Pedzisa *et al*. 2015b) have been reported in SSA including Zimbabwe, though not in mechanized systems (Kassam *et al*. 2014b). Additionally, the young and active rural population is declining as the younger generation migrate to urban areas (Sims and Kienzle 2016) thereby creating labour shortages during the labour peak periods like weeding (Sims *et al*. 2018). Therefore, access to acceptable mechanization by smallholder farmers, can lessen labour burden on women, children and youths (Sims and Kienzle 2016), thereby increasing adoption of CA (Sommer et al. 2014). For the equipment to be acceptable, smallholder farmers need to be aware that the equipment is accessible, available and affordable. On the other hand, the AUC suggested that agricultural mechanization in Africa has to a) satisfy the interests of smallholder farmers especially women and youth b) should be moulded along the value chain approach and driven by the private sector c) need to be friendly to the smallholder farmer and the environment (FAO and AUC 2018).

Humans provide much of the farm power for agricultural production in Africa particularly in sub-Sahara Africa (IFPRI 2016) where majority of the smallholder farmers prepare their land using hand tools, which drives away youths from agriculture (Oluwole and Odogola 2018). According to Mazvimavi (2011), only resource endowed farmer in Zimbabwe may afford ripper tines and direct seeders. On the other hand, the success of no till systems is dependent on effective weed management (Giller *et al*. 2009 which is an important factor in determining the area under CA (Marongwe et al. 2011). Labour burden is one of the reasons for underperformance of CA systems in smallholder farming systems of SSA (Brouder and Gomez-Macpherson 2014). Smallholder farmers in Zimbabwe have coined the hand hoe, basin based Conservation Farming **-** the main typology of CA package that is promoted in Zimbabwe “dhiga ufe” simply translated as “dig and die” since they feel its labour intensive (Andersson *et al*. 2011)**.**

5.1.1 The 5 As framework of access to equipment

Access is defined as the extent of fit between the buyer and supplier (Clark and Coffee 2011). The access dimension of CA equipment can be explored by analysing availability, affordability acceptability, accessibility and awareness. The availability and affordability of machines may determine adoption (Sims and Heney 2017) and effective utilization of CA by smallholder farmers (Wodajo and Ponnusamy 2016). For a technology that requires mechanization to be adopted, there is need to ensure adequate quantities are available at the appropriate time and place. Availability of a technology will influence adoption (Yilma et al. 2011). Additionally, ability to pay and availability of the equipment may also affect adoption of new technologies. On the other hand, the acceptability determines the willingness of farmers (users) to embrace the equipment (Health and Coalition 2013). Acceptability may cover the extent to which the farmer is satisfied with more unassailable after sale services provided by the CA equipment providers. On the other hand, accessibility may refer to the geographical location of the CA equipment providers which may be determined by the time and distance which the farmer has to cover in order to access the service provider of CA equipment. Awareness refers to the extent to which farmers are aware of the advantages of having more efficient CA equipment to complete different tasks. This awareness is critical to generate demand, especially in inaccessible rural areas (Saurman 2016). Therefore, the 5As that could be applied to access to CA equipment are: availability, affordability, accessibility, awareness and acceptability.

However, the subject of mechanization in the smallholder agricultural sector in SSA is a neglected orphan (Sims and Kienzle 2015), yet countries that have witnessed increased agricultural mechanization in SSA have also increased agricultural output while the opposite is true for Zimbabwe, Madagascar, Uganda and Egypt (Kirui and Von Braun 2018). Whereas, Zimbabwe has a tractor density of 35.6 % per 100 km, appear to be highly tractorized compared to other African countries, however, there is very limited access to the tractors by the majority of the smallholder farmers (Kienzle *et al.* 2013).

The importance of timeliness of operations such as: planting (Nyagumbo *et al.* 2017) and weeding (Mashingaidze *et al.* 2012) and the associated yield penalties in delaying the operations are well documented. If smallholder farmers get low yields, they will have low disposable income and hence may not be able to purchase equipment (Sims and Kienzle 2016). Therefore if the issue of agricultural mechanization is not addressed, smallholder farmers in SSA will remain with a patrimony of hunger and poverty. On the other hand, the suitability of CA equipment in southern Africa has always been questioned (Johansen et al. 2012) leading to low acceptance of the equipment.

In light of these facts, this study addresses the problem of access to CA equipment uniquely by using the awareness, availability, affordability, accessibility and acceptability matrix in the context of Zimbabwe.

5.2 Materials and methods

5.2.1 Sampling Techniques

The participants for this study were selected through a multi stage sampling. The first stage involved purposeful selection of three Agro-ecological Zones (AEZ) II, IV and V and then purposeful selection of one districts in each of the AEZ. The districts selected were Chivi, Murehwa and Mutoko. The size of the sample was chosen based on time needed by each participant to complete the questionnaire and not necessary on the total population. Therefore, 360 farmers were randomly selected from the three districts using a list of farmers provided by Agriculture Research and Extension Services (AGRITEX). More adopters were deliberately chosen to investigate their experience as this might influence the neighbouring non-adopters (Brown *et al.* 2018).

Pre - testing was done to establish any potential challenges in answering the questionnaire. The questionnaire was then administered at household level and triangulated through focus group discussions (FGDs), key informant interviews and personal observations. A total of 12 mixed participants took part in the FGDs. Key informants came from AGRITEX, the Rural District Council, Care International, World Vision, Plan International, ward councillors, village heads, church leaders, fertilizer and chemical companies, the Grain Marketing Board and lead farmers.

5.2.2 Measurement of variables

5.2.2.1 Independent variables

The 16 independent variables chosen were: gender of household head, marital status, age, experience in agriculture and conservation agriculture, level of formal education, agricultural training, master farmer training, attendance to agricultural conferences and demonstrations sites, major income source, the number of adult members staying at the household, area under CA, total arable area, main source of labour and belonging to agricultural cooperative.

5.2.2.2 Dependent variable

The opinion of the smallholder farmers towards access to CA equipment is the dependent variable for this study. Five variables that were used to measure the access to CA equipment are: Availability; Affordability; Acceptability; Awareness and Accessibility. Theses access variables and corresponding statements are shown in Table 5.1.

Table 5. 1: The five dimension of access to CA equipment

Dimension of access	Statement representing the access dimension
Availability	Local suppliers have the capacity to meet our demand of CA equipment
Affordability	I can afford to buy CA equipment
Acceptability	I am satisfied with services offered by local suppliers of CA equipment
Awareness	I am aware of the advantages of having more efficient CA equipment to complete different tasks”
Accessibility	CA equipment is within reasonable location in terms of distance and time

The access score for each of the statements was measured using a 3 - point Likert scale. Initially, we had a 5 - point Likert scale that we however changed to a 3 - point Likert scale after pretesting experience. The assigned scores were 3 (Agree), 2 (Neither Agree nor Disagree) and 1 (Disagree). We used a decision rule Likert Model suggested by Williams (2015) to test the level of agreements of the respondents to each of the statement. According this rule, ≥ 2.0 is accepted while < 2.0 is rejected (for a three point Likert scale).

5.2.3 Calculation of reliability

Cronbach’s alpha (*α)* was used to measure the reliability of the questionnaire. The *α* of the 20 respondents used in pretesting was 0.67, which is reasonably strong (Taber 2017). Although values of $\alpha > 0.7$ are usually sufficient (Jonsson and Svingby 2007), some authors however recommend values between 0.65 and 0.85. High *α* values may not be appropriate in a test of scientific knowledge (Taber 2017). However, the items we chose tap into the same knowledge aspect thereby demonstrating face validity (Taber 2017), the items measured somewhat correlate with each other (Yusoff 2011) and were therefore reliable according to the α (Table 5.2).

Table 5. 2: Item Analysis from the SPSS output

	Scale Mean if Item Deleted	*Scale Variance if Item Deleted*	*Corrected Item-Total Correlation*	*Squared Multiple Correlation*	*Cronbach's Alpha if Item Deleted*
Affordability	6.11	4.498	0.289	0.166	0.692
Availability	6.84	4.675	0.504	0.445	0.592
Awareness	6.30	3.997	0.461	0.240	0.601
Acceptability	6.72	4.382	0.484	0.364	0.590
Accessibility	6.83	4.788	0.445	0.300	0.613

α = 0.67; Standardized item alpha = 0.69

5.2.4 Data analysis

Data was analysed using SPSS version 16.0. We used an alpha value of 0.05 in testing the statistical significant of any independent variable in explaining access to equipment. The Pseudo R-squared was used to explain the amount of variance explained by the model. The odds ratio gave us an indication of what happens to equipment access with a unit increase in one of the independent variables while the other variables are held constant.

5.3 Results

5.3.1 Demographic variables

Generally, we found out majority (53 %) of the participants completing the questionnaire were female. Almost three- fourths of the respondents indicated that purchasing of equipment was the major cost associated with CA. Additionally, about two thirds of the respondents indicated that that local agro dealers had no capacity to supply CA equipment. Less than 30 % of the respondents indicated that CA equipment was available in local shops while about two thirds indicated that the local shops had no capacity to repair CA equipment. The majority of the adopters had about 0.1 Ha under CA.

5.3.2 Constraints to accessing CA equipment

Affordability, availability, accessibility and acceptability, with mean scores ranging from 1.32 - 1.94 were the significant constraints (Table 5.3) in accessing equipment.

Table 5. 3: Access dimension to CA equipment by the respondents

Hypothesis	***Mean score***	***Rank***	***Results***
H1: High cost	1.90*	3	Supported
H2: Non-availability	1.36*	2	Supported
H3: Low awareness	2.10ns	N/A	Not supported
H4: lack of after sell services	1.32*	1	Supported
H5: long distance to agro suppliers	1.94*	4	Supported
Overall access score	**1.72***	**N/A**	**Supported**

**: Significant factor at P < 0.05, ns: Not Significant*

5.3.3 Determinants of access to CA equipment

The results of the regression model show that the likelihood ratio statistics is highly significant (Chi ^{2} < 0.0001) meaning that the model used has a strong explanatory power. The Pseudo R – square value of 0.496 indicates that about 50 % of the variation in accessing CA equipment by the farmers was explained by the selected explanatory variables in the model. Among the sixteen variables that were in the model; age, education, experience in agriculture and area under CA were statistically significant (P < 0.05). However, age (B = - 0.569); experience in agriculture (B = - 0.387) had a negative and statistically significant impact on access to equipment. This implies that the odds of accessing equipment were found to decrease if the age (experience in CA) increases. On the other hand, education (B= 7.35) and area under CA (B= 10.23) were found to have a positive and statistically significant influence on access to equipment implying that the odds of access to CA equipment increases if education (area under CA) increases (Table 5.4).

Table 5. 4: Factors influencing access to CA equipment

Variable	B	p- value	Odds Ratio
Intercept	25.486	0.000	
Age	-0.569	0.035**	1.460
Marital Status	6.556	0.82	2.423
Gender	-0.492	0.276	3.990
Education	7.35	0.006***	5.630
Number of adult members	-6.04	0.776	1.380
Agricultural Training	6.615	0.450	3.830
Masters Farmer Certificate	0.350	0.476	1.024
Experience in agriculture	- 0.387	0.007***	1.246
Labour source	1.334	0.127	3.638
Major income source	5.614	0.512	1.321
Farming cooperative	-0.412	0.838	0.220
Attendance to agricultural meetings	1.130	0.55	1.322
Attendance to demos	1.220	0.621	0.400
Experience in CA	13.132	0.318	0.888
Total arable area	10.212	0.520	1.440
Area under CA	10.230	0.044**	1.664

LR Chi Square 163.979

Pseudo R squared 0.496 (P value 0.000)

***, ** and * significant at P < 0.01, P< 0.05 and P < 0.1 respectively

5.4 Discussion

5.4.1 Demographic variables of the respondents

Majority of the adopters have only about 0.1 ha under CA out of total arable area of 1.5 ha. Although the area under CA in Zimbabwe is about 7% of the total arable area, contributing about 35 % of cereal requirements, it has increased food security for the rural households in Zimbabwe (Twomlow *et al*. 2008). The results indicate that the purchase of equipment is the major cost of CA. Previous studies have revealed that only well to do farmers can afford to buy CA equipment (Mazvimavi 2011). Initially, CA was targeted at resource constrained farmers in Zimbabwe, although focus is strongly shifting resource endowed and productive farmers who can afford to buy CA equipment (Marongwe et al. 2012). This has however created stigma on adoption of CA in Zimbabwe. A study from Zaka, Zimbabwe indicated that farmers sarcastically referred CA as 'dhiga ufe' "dig and die", implying that CA is labour intensive and its yield benefits do not match the amount of labour input (Hove & Gweme 2018). Similar sentiments were obtained in Chirumanzu, Zimbabwe (Manyani et al. 2017). This is not surprising given that digging planting basins is the main typology of CA in Zimbabwe (Pedzisa 2016). These basins have to be prepared every season since the soils in Zimbabwe are predominantly sandy and therefore the basins cannot be maintained during the winter period (Mazvimavi & Twomlow 2009).

5.4.2 Significant constraints in accessing CA equipment

5.4.2.1 Non - availability of equipment

The respondents indicated that CA equipment was not available locally. The majority of farmers in Zimbabwe have a strong perception that the yield benefits in CA are mainly due to timely planting, precision fertilizer placement and moisture conservation (Baudron *et al* 2015b). If farmers hire direct seeders from neighbours, timely planting may not be possible since they need a waiting period to get the seeders when demand for the equipment is high. On the other hand, weeds tend to proliferate in the first years after CA adoption (Mtambanengwe *et al.* 2015) and farmers would need at least a knapsack sprayer to deal with the weeds. Manual weeding using the hand hoe becomes labour intensive due to increased weed dynamics (Haggblade and Tembo 2003) and weed density under CA (Mashingaidze *et al.* 2012). The increased weeding frequency increases the labour burden to women (IFAD 2016), who do most of the agricultural work in Zimbabwe (FAO 2017) and Africa in general implying that the labour burden to women may increase with CA (Beuchelt 2016). However, mechanization reduces labour requirements for weeding (IFPRI 2016).

CA adoption is highly unlikely in the absence of sound weed management strategies in the majority of the smallholder systems in Africa (Lee and Thierfelder 2017) hence the need to capacitate rural agro dealers so that they can supply CA equipment (Mazvimavi *et al*. 2010) on a concessionary credit facility. Credit is encouraged unlike free equipment since the later may encourage farmers to adopt practices which they have no faith in (Kassam *et al*. 2014b). Ngoma et al. (2014) recommended phase purchasing agreements of equipment. However, the farmers, majority of whom are financially constrained need long term repayment period. Addressing barriers to mechanization is critical given that in countries where CA has been successful: adequate mechanization has played an important role (Sommer *et al.* 2014). On the other hand, there is also need to build capacity of the smallholder farmers, the research, extension agents, relevant government officials, suppliers of agricultural machinery on sustainable agricultural mechanization anchored on the business models and the value chain approach as suggested by the FAO and AUC (2018).

5.4.2.2 Affordability of equipment

The respondents indicated that they could not afford to purchase CA equipment. Purchase of CA equipment is a capital investment (Pedzisa 2016) and therefore the ability of the smallholder farmers to pay is very important. Imported CA machinery is unaffordable to majority of the smallholder farmers (Sims and Kienzle 2015). Affordability of CA equipment is very important given that if farmers use planting basins, more labour will be required especially in light textured soils where the basins tend to disappear during the winter period (Mazvimavi and Twomlow 2009). This is also corroborated by (Mapfumo *et al.* 2014) who found that farmers in Wedza in Zimbabwe are concerned about the labour demands of CA particularly in the preparations of planting basins. The cost of direct seeders is very prohibitive to majority of the smallholder farmers, although ripper tines are a cheaper option (Andersson and Corbeels, 2014). In this case the Government of Zimbabwe need to capacitate local equipment suppliers through creating enabling regulatory policy so that they design agricultural equipment customer - hire services along the Chinese model (Sims and Kienzle 2016). Having a regulatory frameworks will encourage the participation of many players in the private sector, which is important in lowering the cost of hiring agricultural machinery in Africa, which is very prohibitive in a number of countries (IFPRI 2016). Additionally, the private sector is more responsive to the need of the markets unlike governments which import equipment through concessional loans with no back up services (IFPRI 2016). Such arrangements which come with no guarantee of spare parts have been responsible for creating a "graveyard" of agricultural equipment in SSA (Müller *et al*. 2017). A favourable investment climate exists for the private sector in Zimbabwe given the success of contract farming in cotton and tobacco (Scoones *et al.* 2018), the existence of agricultural cooperatives that can link farmers with banks, input suppliers, technical agents, marketing services and the strong social fabric. On the other hand, the AU has a role to play to enable governments to avail affordable equipment to smallholder farmers and "confine the hand- hoe to the museum" by 2025 (FAO and AUC 2018).

5.4.2.3 Acceptability

The respondents indicated that they had low levels of preference towards CA equipment. According to Knowler *et al*. (2014), CA requires specialised equipment such as direct seeders and ripper tines. Research in Zambia has shown that better training improves proper use of ripper tines by smallholder farmers (Grabowski *et al.* 2014). The Government of Zimbabwe has partnered local industries to produce tailor made CA equipment such as direct seeders and riper tines (Mazvimavi 2011) to promote acceptability of these machines.

Although the Government of Zimbabwe made a bold statement in its comprehensive agriculture policy with regards to the promotion of farmers on correct use, repair and maintenance of farm machinery, not much has been done in this area. This is a paradox given the high number of technical departments such as the Institute for Agricultural Engineering, Department of Agricultural Research and Extension, District Development Fund, and Agricultural and Rural Development Authority, which are all mandated by government to promote agricultural mechanization.

5.4.3 Determinants of access to CA equipment

Age: Age was found to have significant but negative influence on smallholder farmers' access to CA equipment. The odds that a farmer will have access to CA equipment decreases by a factor of 1.46 as the farmer becomes older when all other factors are held constant. Traditional farming methods, dominated by hard muscular work makes agriculture unattractive for the youth (Baudron *et al*. 2015) who are more likely to be flexible in exploring new but more efficient equipment in agriculture. Based on level of education, young people are more likely to avoid dangers associated with incorrect use of herbicides which will motivate them to buy equipment like knapsack sprayers (Giller *et al.* 2009). However, age is one variable that shows both positive and negative results on adoption of new technologies (Curtis 2000). On the other hand, age may in general not have any influence of adopting conservation practices if the benefits are not immediate (Pannell *et al.* 2006).

Formal Education: If all the other variables are held constant, the odds of a formally educated farmer to access CA equipment increases by a factor of 5.63 for a unit increase in formal educational level. Education is an important variable in improving the decision making process as it enhances capacity of individuals to acquire and process information. While education in general is important to improve agricultural productivity, formal education generally opens up the mind of the farmer to knowledge about farming (Oduro-ofori *et al.* 2014) and application of new innovations to one's specific situation (Pannell *et al.* 2006). Also educated individuals who are likely to be employed have better resources to access equipment. This is corroborated by Mazvimavi et al. (2010) who found that resource endowed farmers use ripper tines and direct seeders equipment, provided they have access to markets. On the other hand, if the farmers do not have ready capital, they may have to borrow from banks. However, the majority of the smallholder farmers in Zimbabwe have no appetite for such loans. Educated farmers can decode the equipment manuals if they are not written in local language given that historically equipment which was imported into southern Africa had no English manuals (Sims *et al*. 2012). However, to the contrary, Kohansal *et al*. (2008) found that in Iran, education has a negative correlation to investment in agricultural equipment since agriculture is not the main source of income for the educated farmers.

Experience in agriculture: This had a significant and negative influence on access to CA equipment. The odds of a farmer accessing CA equipment decreases by a factor of 1.246 with each year of experience, all other variables are held constant. This might be explained by the difficulty in changing mind set of farmers especially those that are old and risk averse and would not want to risk investing in technology unless they have observed the benefits. The older farmers are largely conservative (Blair *et al.* 2013) and changing the mind set of older people is as difficult as stopping a bullet train.

Area under CA: The results indicate that area under CA has a causal significant relationship with access to equipment. Implementation of CA on a larger area is critical given the huge overhead costs needed in acquiring equipment for spraying, planting and weeding (Brown *et al.* 2018). The odds that a farmer with more area under CA has access to equipment increases by a factor of 6.8 if all other factors are held constant. CA improves crop yields which might mean more money to spend on purchase of machinery. Although yields improvement are reported where CA is being implemented in smallholder farming systems in southern Africa and Zimbabwe (Thierfelder et al.2015), yields improvement where mechanized CA is being implemented is also well document in Zimbabwe (Mupangwa *et al.* 2016). A causal relationship is expected since increased agricultural mechanization improves agricultural output which can support mechanisation (Kirui and Von Braun 2018).

5.5 Conclusion

The results indicate a very low access to conservation agriculture by smallholder farmers. Access to equipment was significantly constrained by high prices, non-availability of equipment locally and low satisfaction of services offered by existing suppliers. The socio economic explanatory variables of access to equipment were: age, level of formal education, experience with agriculture and area under conservation agriculture. On the other hand, the significant non-socio economic variables were affordability, acceptability, accessibility and availability of equipment.

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CHAPTER 6: Access to markets by smallholder farmers [4]

Abstract

Access to commodity markets may improve profitability of new agricultural technologies. However, majority of smallholder farmers are located in market constrained environments. Therefore, the objective of the study was to identify the barriers to accessing markets by smallholder faming in Chivi, Murehwa and Mutoko, Zimbabwe. Data on socio economic attributes and access to markets variables was collected using a pre - tested questionnaire that was triangulated through focus group discussion, key informant interviews and personal observations. Data was analysed using ordered logit regression. The results indicate a very low mean market access score (1.814). Gender (β = - 1.3196) and age (β = - 0.63198) had inverse but significant ($P < 0.05$) relationship with access to markets. Access to inputs (β = 2.3893), access to extension (β = 1.21) and belonging to a cooperative all had positive and significant ($P < 0.05$) relationship with access to markets. The results indicate that while female farmers and the young cohorts had difficulties in accessing agricultural markets; access to inputs, extension and being part of an agricultural group improved access to agricultural markets.

Key words: profitability, barriers, ordered regression, Zimbabwe.

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6. 1. Introduction

Accessing to commodity markets has been listed among a host of inhibiting factors to adoption of agricultural technologies (Thierfelder et al. 2012). In this study, we define market access as the level of participation in markets by smallholder farmers. Access to markets is therefore a function of distance and time spent on travelling to markets, access to inputs, access to transport, access to extension services, farmer associations and access to credit. According to Johansen et al. (2012), agriculture production system in majority of smallholder farming systems in Africa and Asia are constrained by distorted markets. Thierfelder et al. (2012) identified the lack of access to markets as constraint to marketing legumes in Zimbabwe. Smallholder farmers in Zimbabwe suffer from the “proximity gap” in which they are located too far away from those who can buy produce at a high price and end up selling to middleman, who normally buy products from smallholder farmers “for a song”. In another study, Mungalaba (2015) found that majority of farmers in rural areas of Zambia are constrained by poor access to markets, transport costs because of poor infrastructure.

The challenge of access to markets in rural areas is further compounded by extension related deficiencies. Almond and Hainsworth (2005) argues that extension officers are not equipped with necessary market information which they are supposed to provide to farmers for improved access to markets. Such information include: suitable climate smart crops and existing or potential markets for inputs and outputs. Such information would encourage farmers to grow high value market driven crops. Additionally, it may spur the inclusion of farmers in group value chains in partnership with the private sector. The private sector would then be motivated to make investments in roads, electricity and communication and functional markets. If smallholder farmers are linked to markets, they can become more productive, create rural employment prospects and in the process build adsorptive and absorptive capacities in coping with the vagaries of climate change (FAO 2009). This is the only way increased agricultural growth can go hand in hand with the goal to eradicate poverty (FAO 2009). Market imperfections may reduce land productivity(Jack 2013), which lowers the profitability of using new technologies and discourage adoption of new agricultural practices. However, market access is a function of socioeconomic variables like age, education, agricultural training, belonging to agricultural associations, attendance to agricultural demonstration centres and conferences, marital status, gender, access to extension, number of active household members, distance to markets, access to inputs and credit facilities.

Age: We posit that older farmers have more contacts which enable them to get market related information (Martey et al. 2012). However, younger farmers may also use the internet/smart phones as a primary source of information and thereby improving access to markets. *Education* on the other hand is expected to have a positive effect on market access since educated farmers have greater access to agricultural information. The educated farmers also have good analytical skills to process information (Uematsu and Mishra 2010). This also apples to farmers with *agricultural training* who are posited to have better access to information. Belonging to a *farming group* may not only enhance access to market information but may reduce cost of transaction and improve access to markets (Wossen et al. 2017). A study by Njaya (2014) found out that farmers in Murehwa and Mutoko districts in Zimbabwe have challenges of high cost of transport (Njaya 2014). *Attendance to demonstration centres and shows* may improve access to agricultural information and hence market information. *Marital status:* This variable is expected to increase access to markets. Married individuals have more sources of information through their networks which is expected to increase their awareness levels on market issues (Ahsanuzzaman 2014). If married couples discuss farming issues within the family, they can make better decisions compared to those who are not married (Obayelu et al. 2014). However, the same authors point that the dilemma is that in some rural African systems, men prefer not to discuss farming issues with their spouses but would rather discuss with other men instead.

Additionally, there is prevalence of subordination of women by men in most developing countries. *Gender*: If women have more access to assets and productive resources, they have higher impacts on poverty reduction (Ngomane and Sebola 2010) and yet a larger number women are poor (Harrington and Chopra 2010). More so, in African culture, when farming activities become more productive and marketing is more formalised, men normally take over. Women have challenges in accessing markets because of high transport costs. On the other hand, women do not *access to extension services* and most markets are male dominated (Ngomane and Sebola 2010). Women prefer markets that are closer to the households since they have other households chores to take care of (Ngomane and Sebola 2010). *Number of active household* members is expected to increase agricultural productivity and market access. On the other hand, households with larger farms are expected to have higher production and better access to markets (Pandey and Khiem 2001). *Distance and time spent travelling* to markets may be used as proxy for cost of transport. If farmers spent more time in accessing markets, this increases cost of transport and therefore decreases market accessibility. The other variable that is most likely to improve market accessibility is the *access to input factor*. Access to inputs may improve productivity and enhance market participation (Ngomane and Sebola 2010). Finally, farmers who have *access to credit* may enhance productivity and therefore market participation (Awotide et al. 2015). This study is premised on the need to identify factors that influence access to markets by smallholder farmers in Zimbabwe. This is critical because addressing the barriers to market access improves profitability of the smallholder sector. On the other hand, there is renewed interest to improved access to markets in order to alleviate poverty which is uncharacteristically high in SSA.

6.2 Materials and Methods

6.2.1 Study areas

The study was undertaken in Chivi, Murehwa and Mutoko districts of Zimbabwe. Chivi district is located in the southern part of Zimbabwe in agro – ecological zone V and typically represents many of the semi-arid smallholder farming systems in Zimbabwe. The major soils are the sandy soils derived from granite rocks that have inherently low fertility (Mapanda and Mavengahama 2011). Crop yields in the district are generally low due to low and unpredictable rainfall patterns (Mutekwa and Kusangaya 2006). Murehwa district is located in the northeast part of Zimbabwe, which typically represents a high potential agro –ecological zone IIA. Granitic derived nutrient deprived sand soils are the dominant soil types in the district (Jérôme 2007). The average rainfall is 1000 mm per year (Soropa et al. 2015). Mutoko district is located in the northern eastern side of Zimbabwe. The greater part of Mutoko lies in lies in agro ecological zone IV, and receives between 450 – 600 mm per annum, which is characterized by mid-season dry, spells (Bhatasara 2015). The soils are typically granitic derived course sandy soils, though interruptions of dolerites are found in a few scattered locations (Chikuvire and Mpepereki 2012).

6.2.2 Experimental Model

Factors that determine the access to agricultural markets by smallholder farmers were evaluated by adopting an ordered logit model since access to agricultural markets can have more than two outcomes (low medium and high). The model is expressed as a function of independent variables that included household characteristics, access to inputs, and distance to markets, access to transport, access to extension services, farmer associations and access to credit, while the opinion of the smallholder farmers towards access to markets is the dependent variable.

The ordered logit model is given as $Y = \beta_0 + \sum^{n} j - n\beta jXj + \varepsilon i$

Where, Y= dependent variable; β_0 = and β_1 are the intercept and slope parameter terms respectively (regression coefficients); $\mathcal{E}$ = random error; i = 1….X = independent or explanatory variable.

Multinomial logistic regression (MLR) was used to evaluate factors that determine access to commodity markets. The MLR is an improvement of the binary logistic regression that allows for more than two categories of the dependent or outcome variable. In this case we can have farmers who have very low level of agricultural market participation (subsistence farmers), farmers with average level of market participation (transitional farmers) and farmers with high level of market participation (commercial farmers). The overall level of market participation was obtained by evaluating the Likert responses of the farmers based on a three point Likert model decision rule.

The research was centred on the smallholder farmers because of the need to understand factors that influence the participation of the smallholder farmers in agricultural markets.

We used Stata 14.0 to determine the fitness of the multinomial model by analysing the likelihood ratio test statistics, Chi square and McFadden' Pseudo R-Square.

6.2.3 Data collection and analysis

Data for the study was acquired from smallholder farmers in the three contrasting agro – ecological zones of Zimbabwe during 2017 - 2018. Participants who took part in the semi structured household questionnaire were chosen through multi stage sampling procedure. A pre tested questionnaire was then administered in three wards in each of the three districts. A total of 40 smallholder farmers were randomly selected per ward (15 non-CA and 25 CA smallholder farmers) with the help of trained enumerators. The household head was chosen as the respondent in the questionnaire. In order to validate the findings of the household survey, we held three focus group discussions (FGDs) per district. Each FGD consisted of 12 participants who were selected based on age, gender, and social class. We also interviewed key informants who included government officials in the Ministry of Agriculture, Mechanization and Irrigation Development (MAMID) and other line ministries involved in socio economic development, NGOs, Community Based Organizations (CBOs) and Traditional and Spiritual Leaders and lead farmers in addition to making personal observations. The semi structured questionnaire administered to the head of the household sought to get detailed information on the socio – economic variables of the participants in addition to information on access to extension, agricultural markets and credit facilities on adoption of conservation agriculture. Each of the main construct on access issues had specific questions associated with it. Socio – demographic data was coded, cleaned and then analysed STATA. More specifically, we set an alpha value of 0.05 in testing weather a particular independent variable was statistically significant in explaining access to markets. On the other hand, the Pseudo R-squared was used to explain the amount of variance of the dependent variable explained by the independent variables in the model. Lastly, the log ordered log – odds estimates tells us what happens to market access when exposed to one of the independent variables while other variables in the model are held constant. Odds ratio greater than 1 means increase occurrence of event while less than 1 means decrease occurrence of event.

6.3. Results

6.3.1 Socio demographic data

Majority (53 %) of the households in the three districts are female headed. On the other hand, majorities (71.9 %) of the smallholder farmers were married while the remainder was either divorced/widowed/single/or separated. The results also indicated that agriculture is the main source of income for the majority (83.7 %) of the households. Additionally, the mean agricultural market access score of the 349 participants was 1.814, standard error of 0.08 indicating a low level of market access in the study.

6.3.2 Empirical model validation

The likelihood ratio statistics is highly significant (Chi - squared statistics < 0.0001), implying that the model has strong explanatory power. Specifically, it can be inferred from the Pseudo R-square of value of 0.6928 (Table 6.1) meaning that the variables included in the model explain 69.3 % of the level of participation in agricultural markets.

6.3.3 Determinants of access to markets

Table 6. 1: Determinants of access to markets by smallholder farmers.

Variable	B_1 (Coef.)	Std. Err.	P>|z|
Gender (0 = Female, 1= Male)	-1.319603*	.6120377	0.031
Age (years)	-.631979*	.2719462	0.020
Mobile network	.1803194	.4439902	0.685
Marital status	.2170291	.1844338	0.239
Adult members	.1912272	.4183133	0.648
Education	-.2445781	.4564489	0.592
Agricultural Training	1.740342	3.240397	0.591
Master farmer Certificate	.7437909	.4967536	0.134
Experience in Agriculture	.334615	.2288144	0.144
Major Income Source	-.5184716	.3203505	0.106
Belonging to a social group	-1.351759	1.044953	0.196
Attendance to shows	-.3437016	.9750898	0.724
Attendance to demos	-.2619458	.8525847	0.759
Distance to inputs	-.1794394	.3820403	0.639
Distance to markets	.5789375	.3255665	0.075
Total arable area	-.1816832	.434561	0.676
Years of practicing CA	.1802443	.2660864	0.498
Adoption status	-.7227858	.6659166	0.278
Access to inputs	2.389527*	.2992368	0.000
Access to extension	1.209871*	.4511373	0.007
Belonging to a farming group	.8871734*	.311087	0.004
Access to transport	.6731714	.5794091	0.245
Access to credit	.0611535	.2861759	0.83
Number of interviews	349		
Pseudo R squared	0.6928		
LR Chi^2	541.44*		

* Significant at 5 % probability level.

The results of the ordered logit regression analysis of determinants of access to markets by farmers are presented in Table 6.1.

The results of the ordered logit regression show that gender (β = -1.31960) and age (β = -0.631979) had inverse but significant relationship to agricultural market access while access to inputs (β = 2.389257), extension (β = 1.209871) and belonging to an agricultural association (β = 0.8871734) had positive and significant relationship with access to agricultural markets. However, variables such as marital status, experience in agriculture, years of practicing CA, road network, master farming training , number of adult members, access to transport and credit all had positive but non-significant relationship with access to agricultural markets whereas education, belong to a social group, attending to shows and demonstrations, distance to input source and markets, total arable area, and major income source all had negative but non-significant association with access to inputs meaning they are not relevant factors in explaining access to markets by smallholder farmers.

6.4 Discussion

6.4.1 Socio demographic data

The results show that majority of the respondents derive their livelihoods from agriculture. This is in agreement with some other studies which indicate that agriculture is the main source of livelihoods for more than 70 % of the rural population in Zimbabwe (Maiyaki 2010). Their agriculture production system however is mainly rain fed and vulnerable to the vagaries of climate variability and change, since maize is the major crop as indicated by about three- fourth of the respondents who took part in the survey. The results are corroborated by Maiyaki (2010) who found that maize is a key food security crop in Zimbabwe. The adoption of CSA practices would therefore cushion the smallholder farmers especially against pests and diseases, water stress and soil degradation all of which are expected to be exacerbated by climate change. However, the low level of agricultural market access in the study is not encouraging.

6.4.2 Factors affecting access to markets by smallholder farmers

The findings partly conforms to past research in some aspects although it partly contradicts past findings in some instances. The results show that female farmers have difficulties in accessing agricultural markets compared to their male counterparts. The lack of access to markets by women can be a result of lack of access to market information and extension services (Ngomane and Sebola 2010). From a study in Zambia and Zimbabwe, Ng'ombe et al. (2017) has revealed that men were more likely than women to be visited by CA extension services agents.

The current study shows that the age of the farmer negatively influences access to markets (Table 6.1). This is consistent with previous findings that older farmers, who have more contacts, have better access to make information (Martey et al. 2012). Similar results were also obtained by Amaya and Alwang (2011) who found a positive association between age and access to market by farmers in Bolivia. However, in this era of internet technology, one would expect that younger farmers may have more market information compared to their elder counterparts (Gwaka 2017), provided they can access the internet. According to Aker (2008), access to a cell phone is likely to reduce search costs for information and thereby improving access to markets. On the other hand, cell phones are also critical for accessing price information particularly in developing countries where there are marked disparities and information asymmetry in market prices (Jack 2013). Therefore mobile phones would reduce the problem of farmers getting low prices by getting real time process of commodities (Zivenge and Kavarina 2012). However, mobile phone had no influence on market access in our current study. This might be attributed to cost of data and limited coverage of mobile phones in developing countries (Almond and Hainsworth 2005) and the fact that having mobile phones does not necessarily equate to internet access. According to Government of Zimbabwe (2017), the cost of internet and acquisition of mobile services is very high in the country. This inhibits use of mobile phones by poor households in the context of Zimbabwe (Gwaka 2017). In rural areas, the problem is further compounded by poor network coverage.

Access to inputs plays a critical role in improving access to markets. Farmers who have access to inputs may improve productivity and market participation (Ngomane and Sebola 2010) through use of improved seed varieties, fertilizers, pesticides and herbicides. Therefore, price distortions due to economic situation may hinder farmers from accessing inputs and hence participation in markets. For example, at the time of writing of this paper, the prices of inputs had more than doubled while the producer price of all crops still remained at where they were during the 2017/2018 season. This has implications on productivity in majority of the smallholder farmers, who are constrained by access to inputs.

A variable that is closely related to access to inputs is the issue of cooperatives/farming groups. Belonging to a farming group had a positive ($\beta = .8871734$) significant influence on access to markets (Table 6.1). Rural cooperatives are important in bringing about economics of scale and boasting agricultural productivity (Mhembwe and Dube 2017) through networking and sharing of market related information (Egbetokun et al. 2017). This corroborates earlier work by Moyo (2010) who found the same results in Uganda. The agricultural cooperatives are also important in group bargaining on producer prices and knowledge transfer about natural resources conserving practices in Zimbabwe (Mutami 2015). Mutami (2015) however points out that current farmer organizations, particularly the Zimbabwe Farmers' Union lacks the capacity to influence producer price.

Of the factors that had positive but non - significant association with access to inputs, we used marital status to indicate the contrast in our current study and past research. Egbetokun et al. (2017) indicates that marital status has a negative influence on market participation. This is in sharp contrast to earlier studies by Hlongwane et al. (2014) which indicates a positive significant association between marital status and market participation. However, it is critical to mention that marital status may improve market access through improved decision making process through consultation. Considering those factors that showed inverse but non-significant relationship with access to markets, we used education to explain the contrariety in our findings and past research. Hlongwane et al. (2014) found a positive and non-significant association between education and access to markets while Egbetokun et al. (2017) found a positive and significant association between education and market participation. On the other hand, Mustapha et al. (2017) found an inverse and non-significant relationship between education and market participation. It seems plausible that farmers with higher levels of education obtain their income from off farm activities (Uematsu and Mishra 2010) and this alone does not spur them to improve agricultural productivity.

6.5 Conclusion

Our study examined the determinants of access to markets by smallholder farmers in Zimbabwe. The mean market score was very low. We concluded that gender and age had negative but significant ($P < 0.05$) relationship to access to markets while variables such as access to inputs access to extension, and belonging to an agricultural group all had positive and significant relationship with access to markets.

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CHAPTER 7: CONCLUSION AND RECOMMENDATIONS

7.1 Conclusion

This thesis 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 Chivi, Murehwa and Mutoko districts, 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.

Our 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 three 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 four 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.

Results in Chapter six revealed that smallholder farmers had limited access to markets for their products. Several studies in Zimbabwe have pointed the absence of well-established markets for crops save for tobacco and cotton. Given the prescriptive nature of CA, it is important that farmers have access to markets to enable them to practice rotations and intercropping if they are to accrue benefits of CA.

We 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.

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.

7.2 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.

7.3 Future research needs

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 look at numerically build GIS based indices of market access for each location in order to offer location specific solutions to the challenges of access to markets.

4. 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.