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Impact of conservation agriculture on smallholder farmer livelihoods in Kenya and Zimbabwe

By

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Submitted in partial fulfilment for MSc Environmental Economics (Coursework) of the requirements for the degree

in the Faculty of Natural and Agricultural Sciences

University of Pretoria

March 2023

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Declaration

I declare that the dissertation, which I hereby submit for the degree MSc in Environmental Economics at University of Pretoria, is my own work and has not previously been submitted by me for a degree at this or any other tertiary university.

Name : Linet Mwendwa Kimathi

Signature ……………………………………………

Date ……………13/07/2023……………………………….

Approved by

Name: Prof ED Mungatana

Signature ………………………………………………...

Date ………13-07-2023……………………………………

Acknowledgements

I would like to express my sincere gratitude for Professor ED Mungatana for his input, guidance and effort in supporting me with my research. I am also thankful to the to African Conservation Tillage Network (ACT) for providing the data for the study. I would like to extend specific gratitude to Engineer Saidi Mkomwa for his technical support on conservation agriculture, research design and overall support in compiling this research report.

I will forever be honoured and impacted by the Mandela Rhodes Foundation, that awarded me with a scholarship for my studies and aided me in beginning the journey to completing this degree. I am also indebted to the University of Pretoria for providing further financial support in my studies.

Finally, I would like to thank my friends and chosen family, who gave me the strength and hope to complete this degree when I felt like giving up. It was a long difficult journey, but they reminded me of my greatness. Above all, I thank God for His undying love, mercy, goodness and kindness towards me.

ABSTRACT

Impact of conservation agriculture on smallholder farmer livelihoods in Kenya and Zimbabwe

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To contribute to the conservation agriculture (CA) is considered as that of combining minimum soil disturbance through zero-tillage practices, permanent soil cover through mulching and crop rotation or crop diversification practices. For the purposes of this study, minimum tillage is considered as a tilling of land at a maximum of 30% of total land area in hectares. Adoption of the full CA suite by Kenyan farmers is found to be at a higher intensity than Zimbabwean farmers at 26% and 5% respectively. This can be explained by the statistically significant challenges faced in availability of cover crops by Zimbabwean farmers practicing CA, relative to their non CA practicing counterparts. To contribute to the CA discourse in Sub-Saharan Africa, this study applies the propensity score matching technique to estimate the impacts of CA adoption on the livelihoods of smallholder farmers in Kenya and Zimbabwe. 25 variables were identified and grouped under 4 categories – (1) farm production, (2) food security and income, (3) social dynamics 7 gender disparity, and (4) sustainability & environmental benefits. Data collected from 204 farmers in Kenya show that CA has statistically significant positive impacts on farm production variables e.g., farm yield; food security and income variables e.g., number of meals per day and profit from produce; social dynamics variables e.g., solidarity and social cohesion; gender disparity variables e.g., overall gender disparity; and sustainability and environmental benefits variables e.g., soil fertility. CA has statistically significant negative impacts on forest area cleared per hectare, which was found to have increased for CA farmers and is under the sustainability and environmental benefits category. CA has no statistically significant impact on overall farm workload, in the gender disparity category. Data collected from 202 farmers in Zimbabwe show that CA has statistically significant positive impacts on variables in the 5 categories as well. There was no impact on sorghum production in the farm production category. There was no impact on health and nutrition, number of months food insecure, overall income, costs of production and access to assets, which fall under the food security and income category. There was also no impact on social dynamics variables i.e., overall social dynamics, and sustainability and environmental benefits variables i.e., overall environmental change. There were no statistically significant negative impacts observed in Zimbabwe. Policy implications for the study's findings include implementation of targeted promotion of CA based on farmers' characteristics e.g. promoting CA adoption as an indicator of creditworthiness as those with previous credit access were more likely to adopt CA.

Key words: impact, propensity score matching, conservation agriculture, Kenya, Zimbabwe

TABLE OF CONTENTS

CHAPTER 1 – INTRODUCTION

1.1 Background

This research assesses the impact of adopting Conservation Agriculture (CA) practices by smallholder farmers in Kenya and Zimbabwe on predetermined outcome variables (in specific: farm production outcomes, food security and income outcomes, gender disparity and social dynamics outcomes, and sustainability and environmental benefits outcomes). The production outcomes assessed were total maize, beans and sorghum production as well as farm workload. The food security and nutritional outcomes assessed were number of food insecure months per year, and number of meals per day. The income outcomes assessed were household income, accumulation of productive assets, and total agricultural production costs. The gender and social outcomes assessed were gender disparities and social cohesion. Finally, the environmental outcomes assessed were the impact of CA on soil health and forest area covered.

1.2 Definition of Conservation Agriculture

Conservation Agriculture (CA) is a method of farm management that involves three key components: (1) minimum soil disturbance or zero tillage, (2) permanent soil cover with crop residues i.e. mulching, with some studies suggesting a minimum of 30% soil cover, and (3) crop rotation or diversification of crop species grown (FAO, 2008, Giller et al., 2011, Baudron et al., 2014, Lalani et al., 2017). Ideally, CA should be implemented as a ‘package’ with the combined practice of all three farming practices (Stevenson et al., 2014). CA methods differ from traditional methods, referred to in this study as Conventional Tillage (CT), in that minimal soil disturbance, a soil surface that is permanently covered and diversification of crops, can help promote better soil fertility. Hobbs et al. (2007) distinguish between CT and CA by comparing tillage practices, soil erosion, soil compaction and soil health and show that when practiced fully, CA (compared to the bare soil of CT) significantly reduces wind and soil erosion and encourages healthy soil biota. Conservation agriculture is therefore a farming tool to facilitate “sustainable land management, environmental protection and climate change adaptation and mitigation” FAO (2017:1).

1.1. Known impacts of CA in Sub-Saharan Africa

CA is practiced all over the world, with Africa being no exception. For Sub Saharan African (SSA) farmers with resource constraints, CA can help address the challenges of low income, low mechanisation, labour shortages, and environmental degradation. CA systems lead to reduced labour through better farm economy, reduced costs in machinery and fuel, and time-saving operations from reduced tillage. This in turn permits the development of other agricultural and non-agricultural complementary activities such as saving and investments in capital and the paying of school fees (Corbeels et al., 2014, FAO, 2017, Pannell et al., 2014). CA can also optimize long-term advances in productivity by fostering better water retention, enhanced soil quality and decreased soil erosion (Giller et al., 2009, Kassam et al., 2009, Palm et al., 2014). The resulting increases in yield typically attributed to increased soil health can be used to support food security especially in times of rain shortages aggravated by climate changes (Kassam et al., 2009, FAO, 2017). The reduced labour requirements also play a part in redressing gender disparity by removing obstacles to achieve yield returns for female farmers with labour constraints (FAO, 2011). These combined effects present the adoption of CA as a potential catalyst for long term farming profitability which can improve livelihoods.

However, doubts exist on the suitability and effectiveness of CA, especially for smallholder agriculture in Sub-Saharan Africa. Giller et al. (2009), Pannell et al. (2013) and Corbeels et al. (2014) suggest that CA may not be initially beneficial for crop yields, perhaps resulting from short-term effects such as increased weed pressure that alleviates as the CA system matures. This is disadvantageous for smallholder farmers who are typically low on resources and make decisions of switching agricultural methods based on the immediate returns. Resource-poor farmers have pressing needs to provide for their families and cannot afford to make income sacrifices in the short term despite their long term benefits (Lalani et al., 2017, Pannell et al., 2013). Similarly, mulching with crop residues profoundly alters the flow of resources for the farmer, where several competing uses such as fodder, fuel or construction material for crop residues exist (Corbeels et al., 2014, Giller et al., 2009, Lalani et al., 2017).

1.3 Unknown impacts of CA in Sub Saharan Africa

There is little known about the impacts of CA specifically on gender disparity, food security and social dynamics in SSA. Similarly, the ability of CA techniques to improve soil quality are well studied but there exists limited knowledge on other environmentally beneficial practices such as forest preservation and adaptation practices. There are systematic differences between male and female household heads and farm owners across the continent, with males typically owning larger, more fertile land usually obtained through inheritance (FAO, 2011). Baudron et al. (2009) highlight how CA affects women by increased workloads from weeding but their case studies were based in only two locations in West and Southern Africa respectively. Much literature primarily focuses on the rates of adoption by gender and the adjacent contributing factors. However, little research investigates the impact of CA on gender through more access to credit, labour requirements, income levels as well as food security. As a critical social construct, gender has far-reaching implications for agricultural activities in SSA and there is a need to examine the impacts CA can have on gender roles and how they are applied in agricultural systems.

Food security can be tied to increased productivity levels for CA adopters. However, it is not known precisely how food security can be impacted through CA methods. Mango et al. (2017) examined the impact of CA on a food security metric in Zimbabwe and Mozambique with differing results in both countries. Still, studies in the rest of SSA are lacking i.e. in East and West Africa. In terms of social dynamics, researchers typically focus on the social environment that enable adoption or the perception of adopters and non-adopters of CA (Andersson and D'Souzaba, 2014, Van Hulst and Posthumus, 2016, Zulu-Mbata et al., 2016). The social relations that arise from sharing CA knowledge and techniques have seldom been studied. There is an opportunity to examine the impact of CA on how farmers relate to one another and how institutions arise from CA adoption.

1.4 Impacts of CA in Kenya and Zimbabwe

Rosenstock et al. (2014) found up to a 10% chance of yield increases from switching to CA practices in the western highlands of Kenya. Limitations to positive benefits included competitive uses for crop residues from significant live-stock pressure. Similarly, a lack of market access and insecure land tenure limited positive effects on yield. Baudron et al. (2014) concluded that the competition for crop residues and livestock feed was not as limiting in their Kenyan test sites, going as far as to suggest that crop responses to mulching was highly variable and site specific, depending on the combinations of technologies and processes like water-use efficiency. Minimum tillage without crop rotation was found to have the lowest returns due to inefficient soil conservation particularly when rainfall was heaviest in the central Kenyan highlands (Guto et al, 2011). These findings highlight the opportunities for study on farm production impacts in Kenyan farms. In the same vein, Ndiritu et al. (2014) expressed the lack of empirical studies on the effects of CA on income, credit access, land tenure and other systematic differences that are known to exist in Kenya.

In Zimbabwe, CA systems were found to increase the soil carbon contents compared to conventional tillage methods and weed control was achieved through legume intercropping that formed a closed canopy (Thierfelder et al., 2012). Similarly, soil infiltration and water retention was significantly increased with CA methods and surface runoff that led to significantly reduced soil erosion compared to conventional tillage (Baudron et al., 2012, Thierfelder and Wall, 2009). Maize yield was found to increase for minimum tillage systems coupled with mulching and fertilizer by greater than 50% - conversely, yield was depressed without the use of fertilizer (Nyamangara et al., 2013). Mashingaidze et al. (2012) and Nyamangara et al. (2014) found that labour demand using reduced tillage potentially increased over time. These effects in farm workload are just one example of how CA implementation affects males versus females in different ways, yet little investigation has been done in the area. Similarly, reported income levels of farmer households leading to improved livelihoods are generally linked to increases in yield but the effects of CA on food security have been studied sparingly. Mango et al. (2017) concluded on an insignificant impact of CA on a food consumption score in Malawi and Zimbabwe, but a positive, significant impact on food security in nearby Mozambique. There exists a gap to investigate the changes in food security specifically through the lens of consumption and food availability, specifically in Zimbabwe.

1.5 Relevance of the study

CA promotes sustainable agriculture, improves soil fertility and productive capacity. This in turn can contribute to food security by increasing food production and supporting the nutritional needs of a growing world population. This aligns the adoption of CA with the United Nations Sustainable Development Goal (SDG) 2 that aims “to end hunger, achieve food security and improved nutrition and promote sustainable agriculture” (United Nations, 2020). Specific to the African continent, the adoption of CA also aligns with Aspiration 1, Goal 5, of Agenda 2063 by the African Union (AU), which encourages the development of “modern agriculture for increased productivity and production” (African Union, 2015, 41). Furthermore, improved soil conditions from CA help mitigate against inadequate rainfall therefore improving crop resilience and aiding the adaptation of farmers to climate change (Zulu-Mbata et al., 2016). This resonates with SDG Goal 13, which aims to "strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries" by 2030 (United Nations, 2022). Finally, improvements in workload and the increases in income for female farmers reported in CA adoption aligns with Goal 17 under the "full gender equality in all spheres of life" Aspiration of the AU 2063 Agenda . Thus, this study, in its investigation of the impacts of CA on production, gender disparity and environmental conservation practices, becomes a relevant tool for policy makers to help them achieve the goals set out in relevant policy documents.

This research will investigate the effects of CA in the study areas chosen in Kenya and Zimbabwe, casting a comprehensive look at the outcomes on farm production, food security and incomes, gender disparity, social dynamics and sustainability and environmental benefits. Whereas much is known about the effects of CA on farm production, labour inputs and soil fertility, some important livelihood factors such as food security, gender disparity, and social dynamics amongst farmers are often less considered. This study will present the impact assessment on CA adoption from a more holistic approach, tackling the above-mentioned areas and specifically providing scholarly contributions to the missing areas of gender disparity, food security and social dynamics.

1.6 Problem statement

Studies across the world have indicated the potential CA has to improve various outcomes such as, farm yield, farm workload, food security, income, gender disparity, social dynamics and sustainability and environmental benefits - leading to improved livelihoods and socioeconomic status of households. Whilst many scholars have shown the positive impacts of CA on these outcomes, some have pointed out disadvantages of CA such as implementation constraints and the lack of visible short-term benefits (Corbeels et al., 2014, Giller et al., 2015, Kassam et al., 2009, Lalani et al., 2017, Nyamangara et al., 2014, Palm et al., 2014, Baudron et al., 2012, Giller et al., 2009).

In Sub Saharan Africa (SSA) all of the CA principles are not always fully implemented by farmers and results are not as favourable as expected (Giller et al., 2011). Given this variation, there is a need to investigate the true effects of CA in farmer contexts. It is against this controversy that this study is guided with the following research questions.

1.7 Research objectives

The key question addressed is how the introduction of CA methods by smallholder farmers in two countries, Kenya and Zimbabwe, impacts their farm production, food security and income, gender disparity, social dynamics and sustainability and environmental benefits. Furthermore, how these impacts differ to the use of Conventional Tillage (CT) methods i.e. non-adoption of CA by farmers, will be investigated. This comparison between adopters and non-adopters will help find evidence for or against CA and contribute to the ongoing debate on the merits of CA.

The specific objectives are as follows:

- To determine the impacts of CA on farm production, food security and income, social dynamics and gender disparities and examine if those impacts are positive or negative compared to non-CA practices.
- To investigate the sustainability and environmental benefits of farmers implementing CA and how those effects impact the natural environment.
- To consider how these differences can factor into the extent to which farmers can switch to CA from CT and how these contribute to the constraints and compliments of CA adoption or non-adoption.

1.8 Statement of Hypotheses

Literature has shown that some of the main reasons for adoption of CA can be summarised as follows: (1) yield increases and greater yield stability in the long term (Corbeels et al., 2014, Kassam et al., 2015, Stevenson et al., 2014); and (2) better water use efficiency and water economy in dryland areas (Kassam et al., 2009, Palm et al., 2014); (3) better farm economy (reduction of costs in machinery and fuel and time-saving in operations that permit the development of other agricultural and non-agricultural complementary activities) (Corbeels et al., 2014, FAO, 2017, Pannell et al., 2013); (4) flexible technical possibilities for sowing, fertiliser application and weed control (allows for more timely operations) (Hobbs et al., 2007, Kassam et al., 2015). This therefore suggests that farm yield will increase, and farm workload should decrease if farmers adopt CA. Thus, this study will be conducted to test the following hypothesis:

I. *The implementation of CA by farmers has an impact on farm yield and farm workload compared to those that do not practice CA.*

The reported increases in yield and reduction in labour should collectively work to increase revenue and decrease costs for farmers therefore allowing them better access to adequate food and thus increasing food security. Mango et al. (2017) reported increased food security for farmers practicing CA in Mozambique compared to those that did not. Thus, the following hypothesis shall be tested:

II. *The household food security and income of farmers who implement CA will not be the same compared to those who do not implement CA.*

The implementation of CA has been reported to better social capital amongst farmers where they band together in cooperative behaviours and form institutional arrangements to support CA implementation. Silici (2009) stated that farmers using CA orchestrated local groups to help increase participation and collective action in learning, planning and implementing CA. Another instance is where farmers exchange knowledge and experiences through frequent farmer-to-farmer visits in an effort to share skills and compete amongst themselves (Kaumbutho and Kienzle, 2007). Gender dynamics have also been found to change with females benefitting from reduced labour, increased yield and other significant factors such as increased access to credit (FAO, 2011, Ndiritu et al., 2014). Thus, the following hypothesis is proposed for this study:

III. *The social dynamics and gender disparities for households and farmers that implemented CA will change compared to those that did not implement CA.*

At the landscape level, CA enables several environmental services to be harnessed at a larger scale, particularly cleaner water resources, drastically reduced erosion and runoff, and enhanced biodiversity (Kassam et al., 2009, Palm et al., 2014). Overall, CA as an alternative model for sustainable production intensification offers a number of benefits to the society and the environment that are not possible to obtain with conventional tillage agriculture. Farmers implementing CA should therefore show an affinity for sustainable practices that conserve the natural environment through the skills and knowledge that comes from CA application. Therefore, the following hypothesis will be investigated:

IV. *The sustainable nature of CA will lead to a change in sustainability and environmental benefits by farmers as opposed to those that do not practice CA.*

1.9 Structure of the study

The study will be organised as follows. The introduction chapter, including the background to the study, the problem statement and the research objectives will be the first chapter. Chapter 2 will address a review of the literature most relevant to this study, followed by a description of the study methods and research procedures applied in this study. The methodology chapter will then be followed by the results attained in the study and the respective conclusions. Finally, all the references used in this case study will be listed.

CHAPTER 2 – THEORETICAL AND EMPIRICAL LITERATURE

2.1. Introduction

This chapter begins with the definition of CA and various practices that are similar to CA and offers a distinction between them. The CA practices across Sub-Saharan Africa will then be discussed as well as the adoption rates in the continent, with a final focus on Kenyan and Zimbabwean adoption rates. The following sections will then explore the impact of CA adoption reported across literature on the outcome variables of farm production, food security and income, social dynamics and gender disparity, and sustainability and environmental benefits. To conclude, a summary of the literature review is presented in section 2.6.

2.2. Defining CA and other related terms

Conservation Agriculture (CA) is a method of farm management that involves three key components: (1) minimum soil disturbance or zero tillage, (2) permanent soil cover and (3) crop rotation i.e. diversification of crop species grown (Hobbs et al., 2007, FAO, 2008, Giller et al., 2011, Lalani et al., 2017). Ideally, CA should therefore be implemented as a 'package' with all three methods of farming being practised on the farm (Stevenson et al., 2014).

CA methods differ to traditional methods, referred to in this study as Conventional Tillage (CT) in that in practice, soil disturbance through tillage and ploughing was excessive, in order to loosen the soil and allow for easy seeding. This resulted in disruption of the naturally occurring soil composition, decreased soil productivity, as well as increased soil erosion (Hobbs et al., 2007, Kassam et al., 2009). This led to the short-term benefits of ploughing being overshadowed by long-term decreased soil fertility.

Such conditions made CA a prime alternative to be introduced into the world of agriculture, with many organisations quick to promote it as the future of farming. Hobbs et al (2007) concluded that CA was a productive and sustainable method of farming that required farmers to overlook traditional mindsets and help solve the problem of the growing demand of food production. Similarly, the Food and Agriculture Organisation of the United Nations (FAO) labelled CA as a "practice that sets out to achieve sustainable and profitable agriculture for farmers and rural people" (FAO, 2008:68). Further through time, CA increasingly became a method of agriculture lauded for its sustainability and ecosystem friendliness. The FAO

(2017:1) published an information sheet stating that "Conservation Agriculture is a response to sustainable land management, environmental protection and climate change adaptation and mitigation". The FAO further promoted the adoption of CA principles stating their universal applicability in all agricultural landscapes and cropping systems. This highlights the intended nature of CA, where effectiveness of the method not only involves the conservation of soil, water, and crop residues but also the mindful practice of making sustainable choices in agricultural processes.

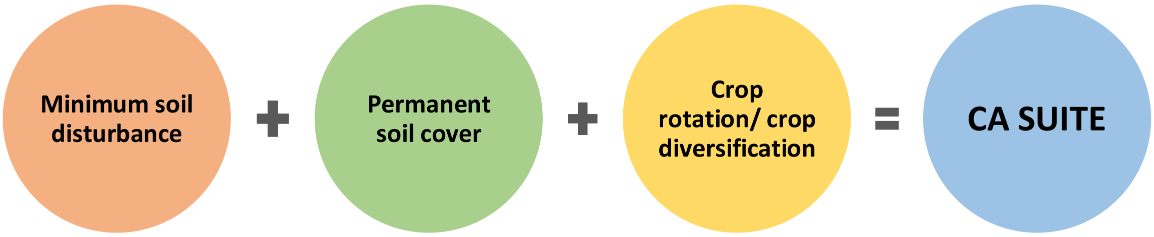
This holistic approach differentiates CA from other 'sustainable-leaning' methods such as zero tillage and conservation tillage, which only focus on one aspect of sustainability and good agricultural practice. Phrases such as conservation tillage, conservation farming and zero tillage have been used interchangeably, at times to describe CA but more often simply referring to no-till areas that are counted as CA adoption (Giller et al., 2015). Hobbs et al. (2007) distinguish between what they call traditional tillage (previously referred to here as conventional tillage), conservational tillage and conservation agriculture. Table 2.1 below highlights these differences.

Table 2.1: A comparison of conventional/traditional tillage, conservation tillage and conservation agriculture on soil

	Traditional tillage (TT)/ Conventional tillage (CT)	**Conservation tillage (CT)**	**Conservation Agriculture (CA)**
Tillage practices	Disturbs the soil and leaves a bare surface	Reduces soil disturbance as compared to TT/CT and keeps the soil covered	Minimal soil disturbance and keeps the soil surface permanently covered
Erosion	Highly susceptible to wind and soil erosion	Wind and soil erosion reduced significantly	Wind and soil erosion at the minimum
Soil compaction	Compaction is actively reduced and possibly induced by destroying of biologically processes	Reduced tillage is used to reduce compaction	Soil compaction can be problematic but mulching and promotion of biological tillage helps reduce this problem
Soil fertility or health	The least healthy of the three owing to frequent disturbance	Moderately better soil biological health	More diverse and healthy biological properties and populations

Source: Adapted from Hobbs et al. (2007:546)

Figure 1: The components of practices of the full CA suite



For the purposes of this study, we're going to consider the practice of the full CA suite as farmers taking part in the CA promoting ACT programme, who practice minimum soil disturbance through zero-tillage practices, together with permanent soil cover through mulching and crop rotation or crop diversification practices of growing maize alternated with legumes such as chickpeas. Minimum tillage is considered as farmers who till the land at a maximum of 30% of total land area in hectares.

2.3. Adoption of CA across Africa

CA is practiced all over the world with Africa being no exception. As of 2013, it was reported that Africa had 1.2 million hectares of cropland under CA, which is 0.8% of the global area and a mere 0.9% of total African cropland. This is compared to 66.4% in South America, 54.0% in North America, 17.9% in Australia and New Zealand and 10.3% in Asia (Kassam et al., 2015). In North Africa, Morocco and particularly Tunisia have shown modest growth in CA adoption with a total of 12 000 ha of cropland under CA in 2013 from 10 000 ha in 2008/9 (Kassam et al., 2015). Still, majority of the CA cropland is found in Sub-Saharan Africa (SSA) at approximately 1.22 Million hectares (M ha) of the region as of 2013/14.

CA has experienced significant increased rates of adoption in recent years, especially in SSA. Kassam et al. (2019) report an increase of 211% of area under CA in Africa: from 0.48 M ha in 2008/09 to 1.2 M ha in 2013/14 and 1.51 M ha in 2015/16. The proportion of SSA hectarage under CA therefore increased from 0.9% to 1.1% of total cropland. In the 2015/16 period, the number of countries globally practising CA increased to 78 from 55 in 2013/14. Of that global increase, a significant amount was credited to Ethiopia, Rwanda, Burkina Faso, Senegal and Cameroon in Africa. In South Africa, Zambia, Zimbabwe, Malawi, Mozambique, Namibia, CA is integrated into national programmes for agricultural development programmes or backed by suitable policies and institutional support to achieve continued adoption. Organisations such as the New partnership for Africa's Development (NEPAD), the European Commission (EC*)*, the ACT and European Conservation Agriculture Federation (ECAF), and other international organisations as well as the private sector, have contributed to the increased uptake, leading to regional and global successes.

Kassam et al. (2015) found that there are at least 15 Sub-Saharan African countries that are now using CA - Kenya, Uganda, Tanzania, Sudan, Swaziland, Lesotho, Malawi, Madagascar, Mozambique, South Africa, Namibia, Zambia, Zimbabwe, Ghana and Burkina Faso. In 2015/16, South Africa was the leading African country practising CA with a total of 439.00 M ha, followed by Zambia at 316.00 M ha, Mozambique at 289 M ha, Zimbabwe at 100 M ha then Kenya at 33.10 M ha (Kassam et al., 2019). These top 5 countries indicate a dedication to CA adoption and this study will focus on Kenya and Zimbabwe, and the relevant impacts that CA has brought to it small holder farmers.

2.3.1. Factors affecting adoption in Kenya

Various organisations and NGOs have collaborated in the country to promote CA adoption. For example, the EU-funded ABACO (agro-ecology based aggradation-Conservation Agriculture) project, which ran in 2011–2015 for semi-arid regions was a project aimed at promoting CA by bringing together a large number of partners working on CA in Africa, including those from international and national research centres, and the African Conservation Tillage (ACT) network (Van Hulst and Posthumus, 2016). The ABACO project established demonstration plots with Farmer Field Schools (FFS) in Laikipia county, Kenya to experiment with, and evaluate, a number of different treatments based on the CA principles. The FFS members were introduced to CA in 2007–2008 during the CA-SARD (CA – Sustainable Agriculture and Rural Development) research project.

In a case study in Bungoma county, Kenya, Ndah et al. (2015) discovered that CA adoption influences were primarily and respectively, (1) the aspects of perceived attributes of an innovation (complexity, trialability, compatibility, observability, relative advantage) as determinants for the adoption of innovations; (2) unsuitable market conditions for inputs and outputs; (3) the extent of change agents' promotion efforts; (4) political/institutional framework at the village level; and (5) the community's attitude towards CA. Essentially, the complexity of CA was the most negative influence towards adoption, and farmers found difficulty in understanding the concept of CA (Ndah et al., 2015). Markets for inputs and outputs greatly affected decisions by farmers when considering adopting CA as well as perceived attributes of the innovation. Similarly, the capacity of the CA promoter to influence the farmers into changing perspectives was an important aspect.

2.3.2. Factors affecting adoption in Zimbabwe

The economic conditions of Zimbabwe present an especially fragile, special case and thus the majority of adoption factors are linked to this. Good market conditions are seen as a prerequisite for adoption in understanding the expectations of CA adoption in the country (Corbeels et al., 2014). The promotion of policy and resource mobilization is also central to the success of CA adaptation in Southern Africa and Zimbabwe (Andersson and Giller, 2012). Powerful international donors and agencies, including the Department for International Development (DFID) in the UK and the FAO, were found to be critical to the initial establishment of CA in communities by providing the resources that allowed its institutionalization (Andersson and Giller, 2012). Similarly, the engagement of international research organizations in the formulation, implementation and evaluation of combined input support and CA programmes had a significant legitimizing effect of the practice (Andersson and Giller, 2012).

Chiputwa et al. (2010) found an inverse relationship between level of disposable income and adoption of zero-tillage implying that households (in the Shamva District of Zimbabwe) with higher disposable income were less likely to adopt and intensify the use of zero-tillage than those with lower income. Richer farmers were considered to have a greater ability to use mechanisation to prepare their lands compared with the poorest ones who are more likely to opt for zero-tillage to reduce costs under conditions of high rental rates for mechanical power (Chiputwa et al., 2010). There was also a positive relationship between cattle ownership and adoption and use of zero-tillage where a unit increase in the number of cattle owned increased the probability of adoption (Chiputwa et al., 2010). Cattle ownership was associated with the ability to raise initial investment capital required to purchase zero-tillage implements like direct-seeders as well as herbicides for controlling weeds.

In a Zimbabwean district case study, CA adoption was initially encouraged by NGOs with free inputs such as fertiliser and seed. These NGOs gradually reduced their support after a few years and the uptake of CA from this intervention undoubtedly have been influenced by this –

similarly, the decrease in CA adoption after the intervention was evident (Kunzekweguta et al., 2017). It was also reported that farmers did not fully implement all elements of CA and instead applied the methods they deemed most suitable for them – 72% practiced reduced tillage, 56% crop rotation and only 9% mulching, presumably due to the competing uses of mulch.

Labour burdens have also been reported in Zimbabwe as a dissuader to adoption of CA where coin basin-based CA as "diga ufe", translated as "dig and die" (Mugandani and Mafongoya, 2020). Furthermore, Lee and Gambiza (2022), find that challenges to adoption of CA in Southern Africa constitute four major categories - physical resources, human resources, informational resources, and financial resources. For physical resources, implementing CA was often impractical due to a lack of machinery access and availability, lack of access to inputs, and tenure insecurity (Lee and Gambiza, 2022). For human resources, the most prominent constraint to CA was labour availability in households. For informational resources, information delivery was a challenge, with the top barriers identified as knowledge gaps, inadequate modification and adaptation, and the failure to connect smallholder farmers to information systems (Lee and Gambiza, 2022). Finally, for financial resources, the necessary machinery and inputs, was not economically viable at the household level (Lee and Gamibiza, 2022).

2.4. CA practices in Sub-Saharan Africa

There has been some argument as to whether the adoption of CA has been well executed by farmers across many SSA case studies. Typically, the adoption of CA by smallholder farmers is markedly smaller than that on large, mechanised farms. Small holder farmers are less able to invest in the tolls and equipment needed to practice minimum tillage and also struggle with mulching. Similarly, they are much more risk averse than large farmers and are lacking in networks, knowledge sharing systems, as well as skill sets, to implement the full package of CA. Therefore, some studies report that only part of the CA suite is applied, especially in the Southern & East African region (Bauldron 2007, Thiefielder and Wall 2012).

The suitability of CA for smallholders in sub-Saharan Africa specifically has been deliberated across the years (Giller et al. 2015; Giller et al. 2011; Giller et al. 2009; Andersson and D'Souza 2014) with the general conclusion being that it is best fit to particular contexts (Wall 2007, Baudron et al. 2015b). Despite numerous benefits for farmers, adoption of the full CA suite has been found to be difficult due to a number of challenges. Thierfelder et al. (2015b), Baudron et al. (2015b) and Andersson and D'Souza (2014) list them as follows in summary: a) lack of knowledge and capacity of farmers to implement CA; b) lack of sufficient biomass retention on the soil surface in intensive crop/livestock systems (Valbuena et al. 2012); c) lack of access to critical CA inputs (e.g. specialized machinery, fertilizer and herbicides); d) high costs of inputs (e.g. for specific seed, fertilizer and herbicides); e) lack of access to credit for initial investments; f) lack of functional output markets for rotational crops; and g) tradition and resistance to change.

Additionally, weed pressure under CA, especially if no herbicides are used, has been identified as one of the main disincentives for smallholder farmers to adopt the technology (Farooq et al. 2011; Andersson and D'Souza, 2014; Giller et al. 2015), and this happens mostly in the first two to three seasons of conversion to CA (Rusinamhodzi 2015; Mazvimavi and Twomlow 2009). Increased weed pressure under CA, if no herbicides are used, may even increase labour requirements for smallholders (Mashingaidze et al. 2012), often affecting women farmers. While herbicides have been proposed to reduce weed pressure under CA (Muoni et al. 2014), their use in smallholder farming systems may be limited in some areas because farmers cannot access and afford them (Andersson and D'Souza 2014). In other areas they have been used more regularly due to input support programs (Ngwira et al. 2014).

2.5. Impacts of CA implementation in Sub-Saharan Africa

Doubts exist on the effectiveness of CA, especially in smallholder agriculture in Sub-Saharan Africa. For example, Giller et al. (2009) argue there are grounds for questioning the potential for CA to contribute to agricultural development in SSA, highlighting a possible mismatch between the requirements that all the CA principles be adopted by farmers, and the circumstances that characterize and constrain smallholder African farming systems.

Giller et al. (2009), Pannell et al. (2014) and Corbeels et al. (2014) all suggest that CA may not be initially beneficial for crop yields, perhaps resulting from direct short-term effects such as increased weed pressure that become less severe as the CA system matures. Hence, the short-term negative impact on crop yield may eventually lead to a yield advantage, particularly in those systems linked with mulching. This is highly disadvantageous for small holder farmers as they are typically low on resources and make decisions of switching agricultural methods based on the returns in income. Many resource-poor farmers have pressing needs to provide for their families and so cannot afford to make income sacrifices in the short term despite their long term benefits (Lalani et al., 2017, Pannell et al., 2014).

Similarly, mulching with crop residues profoundly alters the flow of resources for the farmer, where several competing uses such as fodder, fuel or construction material for crop residues exist (Corbeels et al., 2014, Giller et al., 2009, Lalani et al., 2017). Crop residues provide highly valued feed for livestock in smallholder farming systems in SSA. This means that feed is often in critically short supply, given typically small farm sizes. Furthermore, traditional practices of communal lands for grazing, where livestock are allowed to roam free and feed on crop residues on the farm would mean that to implement mulching practices, farmers would have to fence their areas and incur a high cost (Corbeels et al., 2014, Giller et al., 2015, Giller et al., 2011).

The reported increases in yield are typically attributed to increased soil health and water retention, thus supporting food security through increased productivity. Giller et al. (2009) stated without a doubt that CA practices decreased soil erosion. However, this was dependent on the amount of organic matter input through mulching rather than zero tillage - but only if mulching did not instead result in the promotion of pests and diseases.

Literature has reported mixed results in CA impacts, with some studies reporting economic benefits relative to conventional methods (Mucheru-Muna et al., 2010, Nyamangara et al., 2014). Adoption of minimum tillage practices in a Zambian study was associated with an average yield gain for maize, groundnut, sunflower, soybean and cotton but no significant effects on crop income (from sales and for subsistence) of households in the short-term Ngoma, 2018). Corbeels et al. (2014) found that farm income increased in the long term as opposed to immediate returns. Some findings also show that smallholder farmers find negative returns to investment in CA as compared to large scale and well-resourced farms (Pannell et al., 2014). However, contextual information that colours the economic outcomes of smallholder farmers are important to consider.

Overall, these findings beg the question if full CA adoption in Africa has been too optimistic. Adoption in SSA is often partial, limited in extent both in terms of number of farmers practising CA and in area, and frequently temporary in nature (Giller et al., 2015). It is worth further investigating the factors that affect adoption or dis-adoption especially specific to countries and their respective regions.

2.5.1. Impacts of CA implementation in Kenya

Rao and Mathuva (2000) found that maize rotation with legume-based cropping systems based on cowpea and pigeon pea were 32–49% more profitable than continuous maize in an experiment at the research station of the International Centre for Research in Agroforestry (ICRAF) at Machakos, Kenya. On-farm trials in western Kenya by De Groote et al. (2010) also found that soybean (legume) rotations and legume fodder intercropping with maize were highly profitable compared with conventional systems.

Ayuke, Kihara et al. (2019) found that in areas of Kakamega, Kenya where CA was practised in place of conventional tillage, that increased soil fauna and richness were evident in the medium and long term.

Despite such observed profitability and beneficial impacts, adoption and implementation Van Hulst and Posthumus (2016) concluded that intentions to practice CA were mainly determined by perception. Farmers who intended to implement CA had a more positive attitude towards the practices. They also experienced more social pressure to adopt, and perceived a higher degree of capability to perform the practice – they were therefore more likely to adopt.

2.5.2. Impacts of CA implementation in Zimbabwe

Apart from promoting the growth of organic soil biota, zero tillage should also decrease labour requirements (Kassam et al., 2009, FAO, 2017). Yet, Nyamangara et al. (2014) found that labour demand was twofold due to increased weed growth using reduced tillage practices in Zimbabwe while Lalani et al. (2017) found that labour inputs increased over time. This possible increase in farm workload presents a unique challenge in terms of gender disparity and how CA implementation affects males versus females (Ndiritu et al., 2014).

Ndiritu et al. (2014) outlined various disparities by gender for small scale farmers such as ownership of land, especially the land with more fertile soils, number of livestock owned, labour capabilities and access to credit from financial institutions. In testing the adoption practices of sustainable agricultural practices, it was found that "female plot managers were less likely to adopt minimum tillage and manure for soil fertility management compared with male lot managers." (Ndiritu et al., 2014). These findings correspond with Lee and Gambiza (2022), where a labour burden significantly affected women in Zimbabwe due to the increased need for digging of farm basins that did not exist when practicing conventional tilling methods.

2.6. Conclusion

In conclusion, there exists empirical evidence of the benefits of CA implementation across various regions in the world and in Africa. The sustainable nature of the practice, as well as its ability to increase farm yield in the long run, decrease labour requirements and contribute to soil health, make CA practices a worthwhile endeavour for many farmers. However, the contrast between these favourable results and the low adoption of CA in most parts of Africa is striking.

The trade-offs that exist, specifically for small holder farmers that are characteristic of Sub Saharan Africa, makes it difficult to support CA as a one size fits all solution. Beyond the economic aspects of CA, it may be that attitudes of perceptions towards CA adoption by farmers is also a key factor in determining the (non)adoption of CA. Given these different findings, there exists the need for determining the contexts that make CA adoption a success. This study aims to add to empirical research by conducting a cross country study to unpack contextual differences that might exists, which translate to adoption or disadoption of CA and contribute to the impact of CA on farmer livelihoods..

CHAPTER 3 – METHODOLOGY

3.1. Introduction

This chapter describes the area studied and provides an overview of the research process used in this study. The chapter is composed of six main sections. Section 3.2 outlines the area of the study and the context of the study conditions as well as the data collection process and the resulting data obtained. The method of impact evaluation will be explained in section 3.3 and a discussion on the impact evaluation methods commonly used in literature offered, together with a defence for the specific method chosen for this study – Propensity Score Matching (PSM). The PSM application to this study is explained in section 3.4, including how selection bias was addressed using the data analysis method and the outcome variables selected and analysed are provided. Finally, the chapter is summarised in section 3.5.

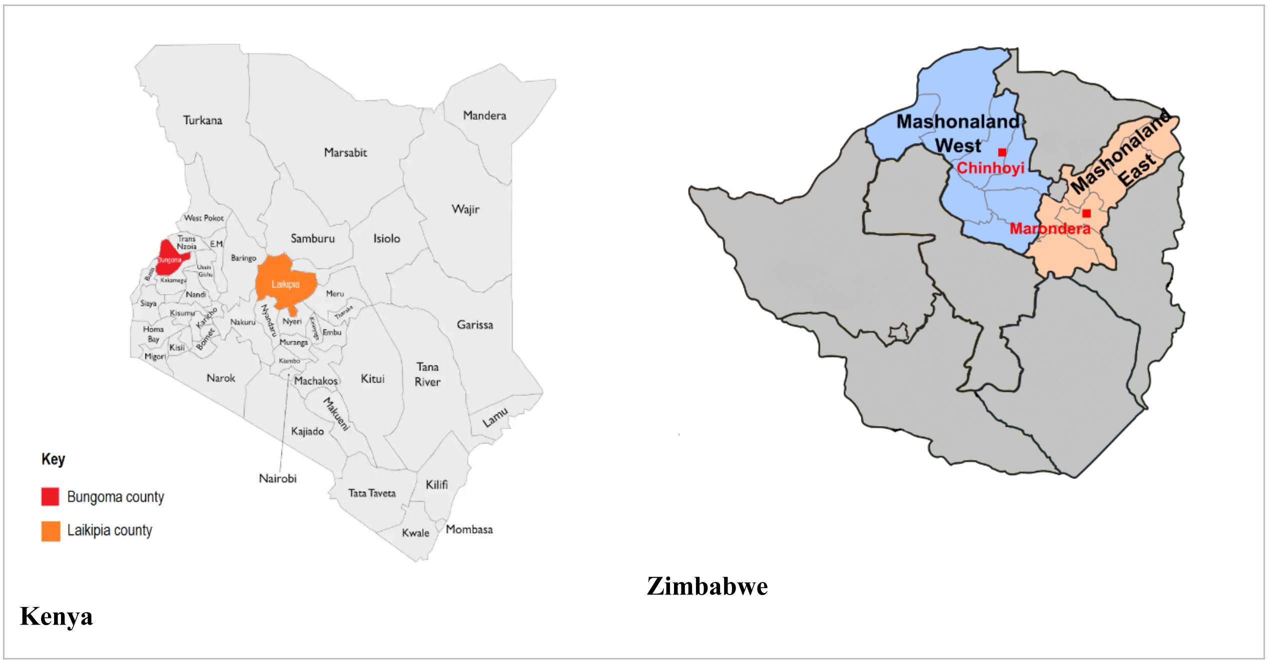
3.2. The study area and context of the study

The Common Market for Eastern and Southern Africa (COMESA) and the African Conservation Tillage Network (ACT), in a joint effort, worked on a project to pioneer conservation agriculture adoption across Africa. After introducing CA practices in various regions across Kenya, Tanzania, Malawi and Zimbabwe, there arose the need to assess the overall project impact. This study will be focused on Kenya and Zimbabwe, where the areas of focus are Bungoma and Laikipia counties in Kenya and the provinces of Mashonaland East and West in Zimbabwe. The location of the study areas were selected by the COMESA and ACT project teams in the respective countries are shown in Figure 2 below.

A set of household interviews with a sample of farmers within predetermined targeted areas were conducted to look at changes in adoption of CA technology by smallholder farmers years after the CA project closure. These interviews were designed to collect quantitative and qualitative data on changes observed such as area of land cultivated, crop yields, change in expenditure patterns and income, soil health, food security, and the gender differentiated effects of CA. Farmers who adopted CA are those who reported practicing CA farming methods for any hectares of their farmland. Non-adopters are farmers who reported to practice CA farming methods on 0 hectares of their farmland.

Data was collected by various project stakeholders from a predetermined questionnaire in the chosen districts participating in CA projects. Overall, there are 204 observations for Kenya and 202 observations for Zimbabwe as was established during the project implementation by COMESA and the ACT. This existing data provided an opportunity for the joint collaboration of the Centre of Environmental Economics ad Policy in Africa (CEEPA) with the ACT to conduct this study.

Figure 2: Maps of the study areas in Kenya and Zimbabwe



Source: Nirazul (2022) ; Wikipedia (2022)

3.3. Data Analysis Method

In selecting the farmers or areas in need of CA intervention, project stakeholders may have selected smallholder farmers they knew or those in most need of assistance. Due to the possibility of self-selection bias on the part of the COMESA and the ACT, it is concluded that Propensity Score Matching is the most suitable method of data analysis. All data analysis will be conducted using the statistical analysis package Stata.

3.3.1. Background and Rationale for using Propensity Score Matching

Literature has found that CA adoption projects do not randomly pick to begin projects or promote CA randomly with farmers (Andersson and D'Souzaba, 2014, Corbeels et al., 2014, Kunzekweguta et al., 2017). They are likely to go to farming areas or farming households that are the most affected by adverse climates such as drought, have the poorest farmers, or have had previous contact with the CA adoption beneficiary projects. As a result, CA adoption is not randomly distributed to farmers in a given farming community and contracted farmers tend to have certain similar attributes resulting in firm-selection and self-selection biases (Minot and Ronchi, 2015, Beaman et al., 2014)

There are multiple data analysis procedures used to address self-selection bias in evaluation studies such as instrumental variables method (IV), difference-in-difference (DID) and propensity score matching (PSM), just to name a few (Pan and Bai, 2015). For this study, the IV method was attempted but not used because the instrumental variables tested – awareness of CA activities in the village and previous CA beneficiaries – did not display an adequate exogenous relationship with other related variables in the study i.e., $Cov(z,\varepsilon) \neq 0$. After failing to find suitable IVs, DID was tested as possible analysis but eliminated due to absence of a baseline survey. Thereafter, the PSM method was resolved as the optimum process to address selection bias in assessing the impact of CA adoption on livelihood outcomes.

PSM is a tool for approximating a randomised trial and reducing selection bias in observational studies, introduced by Rosenbaum and Rubin (1983). Selection bias is when a study sample is not representative of the reference population due to self-selection for treatment or the application of the treatment arising from certain background conditions. It is often not possible or feasible to conduct a randomised control experiment as the counterfactual observation of the treated group is irreversibly non-observable. That is, if a sample population is treated, it is virtually impossible to observe the effect of non-treatment of the same group.

PSM first generates propensity scores – the predicted probabilities that an observation will be chosen for treatment (T = 1), for a given set of covariates – for every observation, whether treated or non-treated. Equation 1 shows this probability in its statistical notation. This allows the presence of a control group made up of non-treated observations with corresponding background covariates and propensity scores indicating their probability of undergoing treatment.

$$P\,(X \mid T = 1) = P\,(X) \tag{1}$$

Next, the common support is generated by looking for an overlap in the distribution of propensity scores for observations in the control group and observations in the treated group. This is the matching process that generates a valid comparison group and allows the further evaluation of outcome variables in the occurrence of a good match (Pan and Bai, 2015). This comparison group is essentially the alternative scenario i.e. non-exposure to treatment of the sample population and is therefore the 'next best thing' to the unobservable counterfactual.

Figure 3 below shows how this condition ensures that treatment observations have comparison observations "nearby" in the propensity score distribution. The average treatment effect (ATE) of the program can then be calculated as the mean difference in variable outcomes across these two groups. This is displayed in equation 2 below as follows:

$$ATE = E(X_{1i}) - E(X_{0i}) \tag{2}$$

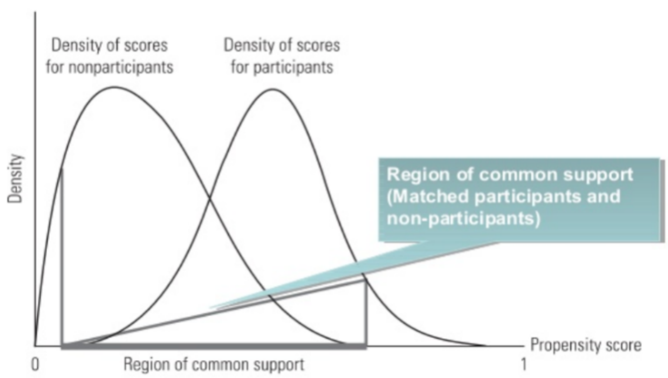
Where X_{1i} = outcome variable under treatment;

X_{0i} = outcome variable without treatment;

$E(X_{1i})$ = Average Effect on the Treated (ATET);

$E(X_{0i})$ = Average Effect on the Controlled (AEC).

Figure 3: The region of common support generated using propensity score distributions. Source: Khandker et al. (2009: 57)



3.4. Application to the study

The livelihood outcomes to be evaluated in this study are grouped into categories that indicate livelihood status for the farmers and have significant impacts on their overall well-being. These categories as outlined in Chapter 1 are (1) farm production, (2) food security and income, (3) social dynamics and gender disparity and (4) sustainability and environmental benefits.

Firstly, to determine if there is selection bias present in the outcomes, standard t-tests will be used to test for significance of a difference in the means of the outcome variables. Table 3.1 below shows the numerous outcome variables that are used for analysis in each impact category. A two-sample t-test will be used to test the hypothesis of a difference in means of the outcome variable, by treatment. Using the number of farmer's meetings attended as an example, a t-test for the following hypothesis will be conducted to determine bias.

Difference = E(No. meetings attended | T = 0) - E(No. meetings attended | T = 1)

H_0: Difference = 0 H1: Difference ≠ 0

Where;

E(No. meetings attended | T = 0) is the mean of the number of farmer's meetings attended, given no treatment occurred

E(No. meetings attended | T = 1) is the mean of the number of farmer's meetings attended, given treatment occurred.

Should H_0 be rejected and the difference in means found to be significant, the propensity score matching will be conducted, using the psmatch2 and pscore commands on Stata. Matching methods that will be used to generate the common support group are namely, Nearest neighbour matching, Caliper or Radius matching, Stratification matching and Kernel matching. This is to allow for robustness by changing the matching algorithm to test for similarity or variation of conclusions when the parameters of the problem have changed.

The list of independent variables that are not affected by subsequent program participation will be used to control for pre-treatment and increase the accuracy of the propensity scores. According to previous studies, typical independent variables are years of education, age of household head and marital status (Chiputwa et al., 2010, Mango et al., 2017, Zulu-Mbata et al., 2016). Based on literature and empirical testing using STATA, the selection criteria for farmers that was used as the independent variables were the following: age, gender, education, whether or not the farmer had previous benefits from a CA project, whether or not the farmer has previous access to credit and whether or not the farmer was aware of CA activities in their village or neighbour villages. The latter three variables were dummy variables where No = 0 and 1 = Yes.

To observe the 4 livelihood impact categories, individual variable outcomes as observed by farmers and as identified in the survey questionnaire by the CA project stakeholders were selected for evaluation. They are outlined in Table 3.1 below.

Table 3.1: Variable outcomes for each impact category as from the data

Outcome category	**Variables applicable**
Farm production	Farm yield, maize production, beans production, sorghum production
Food security and income	*Food security specific variables:* Overall food security, Health and nutrition, number of months food insecure, number of meals per day
	Income specific variables: Sales of produce, access to credit, savings capacity, and reliability of income with CA
Social dynamics and gender disparity	*Social dynamics specific variables:* solidarity, social cohesion and group work
	Gender disparity variables: Overall perceived gender disparity; decreased farm workloadr
Sustainability and environmental practices	Overall environmental change, Forest cleared per year (hectares), soil fertility, adaptation, drought resilience

After matching, the ATE is automatically calculated and compared using each matching method and the pscore function. If selection bias has been well accounted for, each ATE from each matching method should be similar on average. The impacts of treatment, i.e. CA adoption on the livelihood outcome variables can therefore be determined based on the matching results.

3.5. Summary and conclusion

In this section, the area of study and the context of the study was provided as well as the resulting method of impact assessment to be used. The rationale for the chosen data analysis method, propensity score matching, was provided as well as the ways in which the statistical method would be applied to the data and to the outcomes being investigated. Finally, the variable outcomes to be assesed, chosen as relevant to the objectives of this study, were provided.

CHAPTER 4 – RESULTS AND DISCUSSION

4.1. Introduction

This chapter contains sections that describe the different stages of data analysis. To better understand the farmer contexts in both countries, it is beneficial to present a background of the farmer households in Kenya and Zimbabwe. The first section, section 4.2, will begin by presenting the demographics of the farmer households and will outline the similarities and differences between households that adopt CA and those that do not. Table 4.1 presents these demographic statistics of households in Kenya and Zimbabwe.

The latter part of Section 4.3 will tackle the adoption of CA practices in Kenya and Zimbabwe for the different types of CA technologies. The results will show which CA practices were most and least adopted, as well as the combinations of technologies adopted for the three principles of CA namely, minimum tillage, permanent soil cover and crop rotation. Section 4.4 will show how the adoption of these CA practices is related to various outcome variables and how these factors affect the likelihood of farmers adopting CA practices. Finally, section 4.5 will focus on the impact assessment of adoption of CA by farmers and a comparison between these impacts in both countries will be expounded.

4.2. Demographics of farming households in Kenya and Zimbabwe

To investigate significant differences in relevant variables for ACT and Non-ACT farmers in each country, statistical tests were conducted for the equality of means. Table 4.1 shows these results. It was found that the difference in means of household head age for ACT and Non-ACT farmers in Zimbabwe was statistically significant at the 10% level. This means that on average, ACT household heads in Zimbabwe are significantly older than Non-ACT household heads. Similarly, on average, the number of children in Kenyan ACT farming households is higher than Non-ACT farming households at the 10% significance level. This was the case in Zimbabwe as well. On average, the number of adults in Zimbabwean Non-ACT farming homes was higher than ACT farming households. Finally, the differences in the mean total size of land for both Kenya and Zimbabwe were significant at the 5% significance level. Farmers who adopted ACT in Kenya had larger plots on average, while farmers who did not adopt ACT in Zimbabwe had larger plots on average. There was no difference between any other mean statistics of demographics.

Table 4.1: Socio-economic statistics of farming households per country

DESCRIPTIVE STATISTICS	KENYA			ZIMBABWE		
	Non-ACT (83 obs.)	ACT (121 obs.)	P-value	Non-ACT (56 obs.)	ACT (146 obs.)	P-value
Demographics of Household Head (Decision maker)						
Mean age of household head (yrs)	56.36	56.26	0.9449	49.46	54.00	0.0502*
Min age of household head (yrs)	27	33		19	20	
Max age of household head (yrs)	87	77		90	93	
Male household heads (%)	56 (67%)	80 (66%)		34 (61%)	73 (50%)	
Female household heads (%)	27 (33%)	41 (34%)		22 (39%)	73 (50%)	
Literacy rates of Household Head						
Household heads that can read	63 (38%)	104 (62%)		50 (27%)	135 (73%)	
Highest Level of education of Household Head						
No formal education	15 (18%)	8 (7%)		8 (14%)	12 (8%)	
Primary level education	36 (43%)	43 (36%)		16 (29%)	74 (51%)	
Secondary level education	29 (35%)	63 (52%)		32 (57%)	55 (38%)	
University level education	3 (4%)	7 (6%)		0 (0%)	5 (3%)	
Total	83 (100%)	121 (100%)		56 (100%)	146 (100%)	
Members of farming households						
Mean number of children	3.72	4.36	0.0636*	3.25	2.69	0.0569*
Mean number of adults	4.84	4.64	0.4950	2.52	1.98	0.0188**
Mean number of elderlies	0.63	0.58	0.8351	0.54	0.68	0.4562
Land size and land ownership						
Mean total size of land (hres)	1.39	1.71	0.0398**	1.73	1.37	0.0484**
Min total size of land (hres)	0.14	0.20		0.2	6	
Max size of land (hres)	6	8		0.05	8	
Male landowner	56 (67%)	80 (66%)		34 (61%)	73 (50%)	
Female landowner	27 (33%)	41 (34%)		22 (39%)	73 (50%)	

*Source: survey data; ***Significant at 1% level; **Significant at 5% level; *Significant at 10% level*

Literature suggests that the majority of smallholder farmers are subsistence farmers and surplus produce for sale is rarely available if not negligible (Kunzekweguta et al., 2017). Therefore, it was important to understand the economic context of the farmers and their various sources of income. Farmers in both countries report that crop production is a major income source followed by livestock production in Kenya and casual labour in Zimbabwe. ACT farmers in Zimbabwe are more diversified than Kenyan farmers, reporting other businesses, and receiving remittances as other major income sources. Tables 4.2 and 4.3 show these results. This diversification in sustenance for farmers in both countries is important in showing the reliance and degree to which adoption in CA can result in changes in impacts of livelihoods and economic well-being. Kenyan farmers are more likely to require short-term, positive effects from CA compared to Zimbabwean farmers to consider switching as well as more assistance with the adoption and implementation of the techniques due to a lack of other income sources.

Table 4.2: Major sources of income for Kenyan farmers

	1st major source		2nd major source		3rd major source		
	Non-ACT	ACT	Non-ACT	ACT	Non-ACT	ACT	TOTAL
Crop production	82 (99%)	121 (100%)	--	--	--	--	203
Livestock Production	1 (1%)	0	74 (96%)	110 (96%)	--	--	185
Casual labour	--	--	1 (1%)	1 (1%)	18 (62%)	24 (45%)	44
Employment	--	--	--	--	6 (21%)	12 (23%)	18
Businesses	--	--	2 (3%)	0	5 (17%)	9 (17%)	16
Other	--	--	0	3 (3%)	0	8 (15%)	11
Total	83 (100%)	121 (100%)	77 (100%)	114 (100%)	29 (100%)	53 (100%)	

Source: Survey data
Note: Percentages total to 100% column-wise

Table 4.3: Major sources of income for Zimbabwean farmers

	1st major source		2nd major source		3rd major source		
	Non-ACT	ACT	Non-ACT	ACT	Non-ACT	ACT	TOTAL
Crop production	42 (75%)	97 (66%)	--	--	--	--	139
Casual labour	4 (7%)	12 (8%)	13 (29%)	33 (28%)	8 (38%)	13 (22%)	83
Livestock Production	3 (5%)	10 (7%)	13 (30%)	35 (31%)	--	--	61
Remittances	1 (2%)	8 (5%)	9 (20%)	14 (12%)	6 (29%)	21 (35%)	59
Businesses	1 (2%)	9 (6%)	5 (11%)	12 (10%)	0	1 (2%)	28
Employment	1 (2%)	1 (1%)	2 (5%)	7 (6%)	4 (19%)	8 (13%)	23
Other	4 (7%)	9 (6%)	2 (5%)	15 (13%)	3 (14%)	17 (28%)	50
Total	56 (100%)	146 (100%)	44 (100%)	116 (100%)	21 (100%)	60 (100%)	

Source: Survey data
Note: Percentages total to 100% column-wise

4.2.1. Adopters and non-adopters as categorised in this study

For this study, adopters were classified as farmers who reported to have practised CA methods on their farm for any hectares of their total farm area under question under question C1.1 and C1.2 in the questionnaire conducted (please see Appendix). Non-adopters indicated no hectares of land under CA at the time of questioning. CA interventions were implemented by the ACT-COMESA smart agriculture focused projects to tackle global climate change, which were instrumental in recruiting farmers in targeted regions. Therefore, adopters are benefactors of the ACT-COMESA project and are indicated under ACT in the relevant tables, and Non-adopters are indicated under the Non-ACT column. ACT farmers are considered as the treated group, where CA intervention is applied, and Non-ACT farmers as the control group. The impact assessment therefore investigates the differences in specific areas for ACT and Non-ACT farmers years after the CA project(s) closure. The survey respondents in Kenya amounted to 83 Non-ACT farmers and 121 ACT farmers, and in Zimbabwe, 56 Non-ACT farmers and 146 ACT farmers.

4.3. CA adoption rates in Kenya and Zimbabwe

The three broad principles of CA i.e. minimum tillage, continuous soil cover, and crop rotation, are further subdivided into various individual practices (Giller et al., 2009, Kassam et al., 2009, FAO, 2017). The study captured two minimum tillage land preparation practices i.e. subsoiling and ripping; three no-till seeding practices i.e. animal drawn and tractor drawn seeding and jab planter seeding; and five soil cover practices, namely use of manure or fertilizer, leaving of stover in the fields, mulching with imported crops from other fields, uprooting of weeds, and shallow weeding using a weed scrapper. Finally, farmers indicated whether they practiced crop rotation and/or intercropping.

Table 4.4 presents the number of farmers adopting individual CA farming methods for Kenya and Zimbabwe, grouped by practise, and differentiated by ACT project participants and Non-ACT participants. Considering that farmers can practice multiple technologies simultaneously, the row-wise totals will not necessarily equal.

Table 4.4: Adoption of CA technologies by farmers per country

Type of technology	KENYA		ZIMBABWE	
	Non-ACT (83 obs.)	ACT (121 obs.)	Non-ACT (56 obs.)	ACT (146 obs.)
ADOPTION OF NO TILLAGE PRACTICES				
Ripping land preparation	0	76	2	19
Subsoiling land preparation	0	4	1	7
Animal drawn no till seeding	0	19	1	3
Tractor drawn no till seeding	0	0	0	1
Jab planter no till seeding	0	18	0	0
ADOPTION OF SOIL COVER PRACTICES				
Use manure or fertilizer	36	118	18	107
Leave crops in field after harvesting	3	90	14	105
Mulching (imported from other fields)	0	19	3	140
Uprooting weeds (not cutting)	7	93	7	112
Shallow weeding (weed scrapper)	0	115	12	72
ADOPTION OF CROP ROTATION PRACTICES				
Crop rotation	22	106	12	115
Intercropping	30	119	6	14

Source: Survey data

The results show that in both countries, ripping was the more widely practiced land preparation technique with 76 farmers in Kenya and 21 in Zimbabwe implementing the practice as compared to 4 (8) farmers in Kenya (Zimbabwe) practicing subsoiling. No-till seeding practices are not well adopted by farmers in both countries. The most frequently practiced technology is animal drawn no-till seeding, with 19 and 4 farmers practising the technology in

Kenya and Zimbabwe respectively. The study established through further analysis that smallholder farmers preferred manual no-till seeding techniques such as planting basins, and sowing in a hole with a machete as alternatives to the promoted no-till technologies (see Table A.4 in appendix).

For permanent soil cover, the leading technology practices are the use of manure or fertilizer, leaving crop residues in the field after harvesting, and using mulch imported from other fields. 154 smallholder farmers in Kenya and 125 in Zimbabwe use manure or fertilizer for permanent soil cover. For both countries, leaving crops in the field after harvesting is generally also a preferred method of soil cover.

Shallow weeding using a weed scrapper is the most practised weeding technique in Kenya, as compared to uprooting weeds. This is the opposite to Zimbabwe. Finally, Table 4.2 shows that crop rotation is largely practiced by both Kenya and Zimbabwe, but intercropping is very high in Kenya only. To better compare adoption rates of each technology, the intensity of adoption was calculated in the section following.

4.3.1. The intensity rate of CA adoption in Kenya and Zimbabwe

The intensity of adoption for all the practices is defined as the proportion of farmers practicing the specific technology for the Non-ACT and ACT groups. Table 4.5 below shows a breakdown of intensity of adoption rates for the CA technology in each row, grouped in the respective columns per country.

The highest intensity of adoption for a specific CA technology is the use of manure or fertiliser to achieve permanent soil cover and intercropping by ACT farmers in Kenya. That is, 98% of the 121 ACT farmers in Kenya practiced permanent soil cover using manure or fertiliser and practiced intercropping. This is followed by shallow weeding using a weed scrapper (95% in Kenya) and mulching with crops from other fields (90% in Zimbabwe).

Table 4.5: Intensity of adoption of CA technologies per country

Type of technology	KENYA		ZIMBABWE	
	Non-ACT (83 obs.)	ACT (121 obs.)	Non-ACT (56 obs.)	ACT (146 obs.)
Adoption of single no tillage practices				
Ripping land preparation	0%	63%	4%	13%
Subsoiling land preparation	0%	3%	2%	5%
Animal drawn no till seeding	0%	16%	2%	2%
Tractor drawn no till seeding	0%	0%	0%	1%
Jab planter no till seeding	0%	15%	0%	0%
Adoption of single soil cover practices				
Use manure or fertilizer	43%	98%	32%	73%
Leave crops in field after harvesting	4%	74%	25%	72%
Mulching (from other fields)	0%	16%	5%	96%
Uprooting weeds (not cutting)	8%	77%	13%	77%
Shallow weeding (weed scrapper)	0%	95%	21%	49%
Adoption of single crop rotation practices				
Crop rotation	27%	88%	21%	78%
Intercropping	36%	98%	11%	10%

Source: Survey data

The intensity of adoption of minimum tillage practices is generally the lowest for both Kenya and Zimbabwe. Empirically, minimum tillage practices are the hardest to implement due to factors such as lack of access to appropriate equipment. Kaumbutho and Kienzle (2007) and Lee and Gambiza (2022) note that access to subsoilers and no-till seeding equipment is limited for small holder farmers as capital investments are usually needed to buy the equipment, which explain the very low adoption intensity by both countries. For both countries, land preparation by ripping is the most widely practised no tillage method by both Non-ACT and ACT farmers as ripping can be done by hand.

In Kenya, mulching using crops imported from other fields is not as widely practised as in Zimbabwe. This can be explained by the highly competitive uses for crop residues such as livestock feed and fuel (Baudron et al., 2012, Andersson and D'Souzaba, 2014) (see also Table 4.7, where Kenyan farmers specify these competitive uses for mulch as a challenge to adoption). In Zimbabwe, uprooting weeds was the most commonly practiced weeding technique to maintain soil cover, followed by shallow weeding using a weed scrapper. The opposite is observed in Kenya. This is consistent with a case study in the country that states, "conservation agriculture farmers mainly [control] weeds by manually uprooting them, slashing them with a *panga* or scraping them with a hand hoe" (Kaumbutho and Kienzle, 2007, 90). Further investigation of weeding techniques by farmers (please see Table A.5 in the Appendix) shows that farmers in both countries preferred early weeding. Early weeding is more practical as weeds are smaller and thus various weeding techniques by hand are more effective.

Traditionally, smallholder Kenyan farmers would intercrop maize and beans to diversify cropping options for greater yield and increased household income (Kaumbutho and Kienzle, 2007, Menale Kassie et al., 2015). Similarly, intercropping was a common farming practice amongst farmers in Southern Africa. However, policies and foreign farming practices introduced by settlers and missionaries discouraged such technologies, leading to the spread of monocropping (Page and Page, 1991). This could explain the low adoption rates of intercropping in Zimbabwe, despite traditional farmer knowledge in SSA.

4.3.2. Overall Adoption of the CA suite in Kenya and Zimbabwe

Further interpretation of adoption practices was conducted in the study by analysing the adoption of combinations of practices. Table 4.5 first summarises the intensity rates of farmers who practice at least one technology from no tillage principles, at least one technology from the permanent soil cover principle or at least one technology from crop rotation principles.
A combination of at least one soil cover technology and at least one crop rotation technology would lead to a combined practice of two CA principles. Similarly, a combination of at least one soil cover technology and one no tillage technology or one crop rotation and one no tillage technology is also possible. Table 4.6 shows the summary of the intensity rates of these combinations by farmers per country. To fully implement CA, it is required that all three principles be adopted (Farooq and Siddique, 2015, Kassam et al., 2009). Farmers that practice at least one practice of no tillage technology, at least one technology from permanent soil cover and at least one technology from crop rotation practices were considered to practice the full suite of CA principles. Table 4.4 also shows the percentage of farmers surveyed who adopted the full suite and therefore could be considered as practising true CA methods.

The practice of at least two combination of technologies is observed in both countries, with permanent soil cover and crop rotation being the most adopted both by Non-ACT and ACT farmers. This is consistent with literature as discussed previously discussed and as shown in Tables 4.5 and 4.6; crop rotation is a traditional practice among farmers and mulching was found to be the most implemented using manure or fertilizer or uprooting weeds

Table 4.6: Adoption of multiple technologies leading to combinations of practices

	KENYA		ZIMBABWE	
	Non-ACT (83 obs.)	ACT (121 obs.)	Non-ACT (56 obs.)	ACT (146 obs.)
Farmers adopting at least one technology from two CA principles				
Permanent soil cover and crop rotation	17%	50%	10%	41%
No tillage and permanent soil cover	0%	39%	2%	7%
No tillage and crop rotation	0%	38%	1%	7%
Farmers adopting at least one technology from *all three CA principles*				
No tillage, soil cover and crop rotation i.e. full suite	**0%**	**26%**	**0.6%**	**5%**

Source: Survey data

Only 26% of ACT farmers in Kenya implemented the full CA package and a meagre 5% in Zimbabwe. Still, Kenya's full suite adoption rate amongst ACT farmers is much higher than Zimbabwe's which shows some success in encouraging full adoption by the ACT project amongst farmer participants. A very small proportion of Non-ACT farmers in Zimbabwe (0.6%) were found to implement the full suite of CA, despite their categorisation of no CA practice. This could be that farmers practicing the 3 CA principles are doing so out of best practices or observed benefits from CA farmers, despite nonparticipation in the project.

Andersson and D'Souzaba (2014), Giller et al. (2011) and (Giller et al., 2009) state that implementation of the full suite of CA across Sub-Saharan presents challenges such as difficulties in sourcing cover crops seeds for intercropping, labour constraints in weed management, no visible short-term benefits for smallholder farmers and the lack of institutional and policy environments that encourage CA adoption. Kaumbutho and Kienzle (2007) also cite challenges to accessing equipment and capital investment to implement no tillage practices as an inhibitor to adoption.

To further analyse the context specific challenges, the survey respondents were asked to indicate the major challenges experienced in the implementation of CA. The section below summarises the findings.

4.3.3. Challenges faced in adoption of CA technologies

The low adoption rates of no tillage for both countries and the full CA suite specifically for Zimbabwe can possibly be explained by examining the challenges to adoption reported by farmers. A question asking farmers to rank the challenges they faced from 1 (Least Challenging) to 5 (Most Challenging) was posed in the questionnaire (please refer to section A.2 in the Appendix for more details on the questionnaire). Table 4.7 shows the number of farmers who indicated each challenge as the "Most Challenging" as well as the p-values for tests of equality in the distributions of challenges faced by farmers in each country. Table 4.8 similarly shows the "Most Challenging" obstacles and the p-values for tests of equality in the distributions of challenges by each farmer category.

The biggest challenge cited by farmers in Kenya was the widespread use of crop residues for livestock feed and fuel. This is a commonly cited problem of CA adoption and is well documented across literature (Van Hulst and Posthumus, 2016, Giller et al., 2011). The second most pressing challenge was lack of knowledge on the potential benefits of CA. In Zimbabwe, the lack of appropriate CA equipment available was the most cited primary challenge, followed by the high costs of CA tools and equipment. This can explain the low adoption rates of CA, with only 5% of ACT farmers practising the full CA suite in Zimbabwe (Table 4.6). This is not surprising, considering the economic pressures of the country and the socio-economic realities of smallholder farmers, especially in rural areas where access to inputs, tools and equipment is difficult.

A chi-squared test for the equality of distributions was conducted to test for similarities in challenges faced by ACT and Non-ACT farmers in both countries and the results are reported in Table 4.7. The following null hypothesis was tested.

H_0: Distribution of the Non-ACT farmer challenges in Kenya (Zimbabwe) is equal to the distribution of the ACT farmer challenges in Kenya (Zimbabwe).

From the chi-squared test, we do not reject the null hypothesis at all significance levels for all challenges except for the fixed mindsets of agriculture leaders and extension agents in Kenya (we reject the null at the 10% significant level) and the availability of cover crops in Zimbabwe (we reject the null at all significance levels). This means that in general, the challenges faced by Non-ACT farmers are the same as the challenges faced by ACT farmers in both countries. Therefore, there may be difficulty in convincing Non-ACT farmers to switch to CA farming methods as challenges do not alleviate. Additionally, it explains why CA adoptions are low if the challenges faced were the same for both farmer categories in Kenya and Zimbabwe.

Table 4.7: Challenges faced by farmers in adopting CA technologies per country

Adoption challenges faced by farmer stated as the "Most Challenging"	KENYA			ZIMBABWE		
	Non-ACT (83 obs.)	ACT (121 obs.)	P-value	Non-ACT (56 obs.)	ACT (146 obs.)	P-value
Lack of appropriate CA equipment	28 (34%)	40 (36%)	0.920	38 (68%)	96 (62%)	0.777
Lack of knowledge on the potential benefits of CA	43 (52%)	58 (48%)	0.587	23 (41%)	59 (40%)	0.932
High costs of CA tools and equipment	23 (28%)	34 (28%)	0.952	29 (52%)	93 (64%)	0.121
Widespread use of crop residues for livestock feed and fuel	49 (59%)	66 (55%)	0.525	5 (9%)	12 (8%)	0.871
Lack of government policy for CA support	41 (49%)	53 (44%)	0.431	8 (14%)	15 (12%)	0.422
Traditions and culture	20 (24%)	42 (35%)	0.105	2 (4%)	11 (8%)	0.304
Fixed mindsets of agriculture leaders, extension agents	22 (27%)	48 (40%)	0.052*	2 (4%)	3 (2%)	0.535
Availability of cover crops seeds	9 (11%)	7 (6%)	0.187	8 (14%)	51 (35%)	0.004***
Burning of crop residues	2 (2%)	6 (5%)	0.357	4 (7%)	7 (5%)	0.510

*Source: Survey data ; *** Significant at 1% level; * Significant at 10% level*
Note: Percentages show the proportion that reported the challenge of the total number of observations for that farmer group

In Kenya, the challenges faced by ACT farmers due to the fixed mindsets of agricultural leaders differ from those faced by Non-ACT farmers. This makes economic sense because Non-ACT farmers are following conventional farming methods and therefore would not face opposition from local leaders. The same results could be expected in Zimbabwe, however, there are too few observations to show a marked difference in distribution (2 Non-ACT and 3 ACT farmers. This means that the fixed mindsets challenge was not a major issue in the country.

To investigate differences in challenges faced by farmers in each country, a chi-squared test was conducted, by farmer group. Table 4.8 shows the results of the test. The null hypothesis tested for equality of distribution through a chi-squared test is as follows:

H_0: The distribution of the challenges faced by Non-ACT (ACT) farmers in Kenya are equal to the distribution of the challenges faced by Non-ACT (ACT) farmers in Zimbabwe

Table 4.8: Challenges faced by farmers in adopting CA technologies per farmer category

Adoption challenges faced by farmer stated as the "Most Challenging"	Non-ACT			ACT		
	Kenya (83 obs)	Zim (56 obs)	P-value	Kenya (121 obs)	Zim (146 obs)	P-value
Lack of appropriate CA equipment	28 (38%)	38 (68%)	0.000***	40 (33%)	96 (66%)	0.000***
Lack of knowledge on the potential benefits of CA	43 (52%)	23 (41%)	0.214	59 (49%)	59 (40%)	0.171
High costs of CA tools and equipment	23 (28%)	29 (52%)	0.004***	35 (29%)	93 (64%)	0.000***
Widespread use of crop residues for livestock feed and fuel	49 (59%)	5 (9%)	0.000***	66 (55%)	12 (8%)	0.000***
Lack of government policy for CA support	41 (49%)	8 (10%)	0.000***	53 (44%)	16 (11%)	0.000***
Traditions and culture	21 (25%)	2 (4%)	0.001***	42 (35%)	11 (8%)	0.000***
Fixed mindsets of agriculture leaders, extension agents	22 (27%)	2 (4%)	0.000***	48 (40%)	3 (2%)	0.000***
Availability of cover crops seeds	9 (11%)	8 (14%)	0.543	7 (6%)	51 (35%)	0.000***
Burning of crop residues	2 (2%)	4 (7%)	0.178	6 (5%)	7 (48%)	0.951

Source: Survey data
***Significant at 1% level

Using the p-values, we reject the null hypothesis of equality of distributions for all challenges, at all levels except for (1) lack of knowledge on the potential benefits of CA, (2) burning of crop residues and (3) the availability of cover crops seeds for *only Non-ACT farmers*.

(1) Lack of knowledge on the potential benefits of CA

Interestingly, for both ACT and Non-ACT Kenyan farmers, more farmers than in Zimbabwe reported this experience as a greater challenge. Thus, Kenyan farmers across the board were unclear about the potential benefits of CA. This implies that during the implementation of the ACT project, information concerning the advantages of CA were not well communicated or presented to farmer participants in Kenya as compared to Zimbabwean farmers. It will be beneficial to compare the methods of communication used in Zimbabwe by ACT agricultural representatives to promote CA and consider its application in the Kenyan context. These findings correspond with Lee and Gambiza (2022), who cite lack of CA related information delivery as a major challenge to adoption.

(2) Burning of crop residues

Burning of crop residues can be explained by the practice of slash-and-burn techniques as a method of clearing foliage and releasing nutrients into the soil after a harvest and controlling potential pests (Kitch et al., 1997). The observations in the data set are small with only 6 farmers citing this major challenge in Kenya and 13 farmers in Zimbabwe. However, it is plausible that more Zimbabwean farmers find this a challenge than Kenyan farmers because slash-and-burn practices are commonly practiced in Southern Africa as compared to East Africa.

(3) The availability of cover crops seeds for *only Non-ACT farmers*

Finally, Non-ACT farmers in both countries find obtaining cover crop seeds as a major obstacle to CA adoption. This is consistent with literature that has found CA adoption is usually promoted by projects and organisations that make seeds available or access to channels of sourcing inputs to farmer participants (Andersson and Giller, 2012). However, this challenge can be a motivating factor for the adoption of CA dependant on the adoption project promoted in the area and the available seeds offered for participation.

4.4. Assessment based on self-reflexive controls

The impacts of CA adoption in Kenya and Zimbabwe can be observed through the following outcome variable categories - farm production, food security and income, social dynamics and gender disparity, and environmental changes. These outcomes were determined by asking survey respondents in each country various questions relating to changes in yield, food security, income, access to resources, labour, farmer relations and environmentally linked practices. Answers by ACT farmers after CA adoption and by non-ACT farmers after non adoption helped indicate if these aspects of their livelihoods had improved, remained stagnant, or decreased. The overall outcome variable categories can be further subdivided into outcome variables observed by farmers as identified in the survey questionnaire as demonstrated below.

- Farm production – farm yield, maize production, agricultural bottlenecks, and total product sales
- Food security and income – number of meals per day, number of months food insecure, access to credit, and savings capacity
- Social dynamics and gender disparity –solidarity, social cohesion and group work, overall gender disparity, and decreased farm workload
- Sustainability and environmental benefits – soil fertility, forest area cleared, drought resilience and adaptation

4.4.1. Farm production variables

Farmers were asked questions related to overall farm yields, farm workload, agricultural bottlenecks, and product sales after CA implementation. A higher proportion of Zimbabwean farmers reported increases in farm yield compared to Kenyan farmers, but no Kenyan farmers reported decreases in yield compared to 1% of Zimbabwean farmers.

Majority of ACT farmers in both Kenya and Zimbabwe report reduced workloads due to CA implementation as well. This allows them to focus on other production centred activities that improve yields. CA therefore shows the ability to improve farmer livelihoods. Kenyan farmers however report a greater reduction in workload compared to Zimbabwean farmers. Finally, improvements in bottlenecks and product sales are disproportionately greater in Kenya and Zimbabwe, implying greater effects on farm production changes for Kenyan farmers. This implies that CA has a greater impact in Kenya, and the implementation of CA methods is followed more precisely in Kenya. This has implications in the implementation of CA adoption programs between the two countries including the training programs and skills sharing methods used for farmers. Table 4.9 shows these results by farmer category and country.

Table 4.9: Production related variable outcomes from farmer self-evaluation reports

	KENYA (204 farmers)			ZIMBABWE (202 farmers)		
	Non-ACT (83 obs.)	ACT (121 obs.)	Total (overall)	Non-ACT (56 obs.)	ACT (146 obs.)	Total (overall)
	CA effect on overall agricultural yield					
Increased	1 (1%)	119 (98%)	120 (59%)	7 (13%)	139 (95%)	146 (72%)
No effect	82 (99%)	2 (2%)	84 (41%)	47 (84%)	6 (4%)	53 (26%)
Decreased	0	0	0	2 (4%)	1 (1%)	3 (1%)
Total	83	121	204	56	146	202
	CA effect on farm workload					
Reduced workload	2 (2%)	99 (82%)	101 (50%)	3 (5%)	85 (58%)	88 (44%)
No effect	2 (2%)	21(17%)	23 (11%)	18 (32%)	55 (38%)	73 (36%)
Unsure	79 (95%)	1 (1%)	80 (39%)	35 (63%)	6 (4%)	41 (20%)
Total	83	121	204	56	146	202
	CA effect on agricultural calendar bottlenecks					
Improved bottlenecks	1 (1%)	119 (98%)	120 (59%)	5 (9%)	90 (63%)	95 (47%)
No effects	82 (99%)	2 (2%)	84 (41%)	45 (80%)	41 (28%)	86 (43%)
Worsened bottlenecks	0	0	0	6 (11%)	15 (10%)	21 (10%)
Total	83	121	204	56	146	202
	CA effect on product sales value in USD					
Increased	0	105 (87%)	106 (95%)	2 (4%)	92 (63%)	94 (47%)
Stagnated	83 (100%)	16 (13%)	6 (5%)	53 (95%)	54 (37%)	107 (53%)
Decreased	0	0		1 (2%)	0	1 (1%)
Total	83	121	204	56	146	202

Source: Survey data; Note: The percentages total to 100% column-wise

4.4.2. Food security and income

4.4.2.1. Food security

Food security is an important impact outcome to CA adoption as higher food security can end poverty, improve health and nutrition and result in long term improved wellbeing (Mango et al., 2017). Kenyan and Zimbabwean farmers reported their observed food security and health and nutrition given CA adoption and based on their perceived access to food and nutritional value food sources in their households; from sources such as their own farmland; purchased food; and food given by their neighbours, friends and relatives. Food security and health and nutrition are reported to have overwhelmingly increased given CA. Non-ACT farmers in both Kenya and Zimbabwe however show unclear responses to the effects of CA, which is expected given their lack of adoption. Table 4.10 shows these results.

Table 4.10: Food security related variable outcomes from farmer self-evaluation reports

	KENYA (204 farmers)			ZIMBABWE (202 farmers)		
	Non-ACT (83 obs.)	ACT (121 obs.)	Total (overall)	Non-ACT (56 obs.)	ACT (146 obs.)	Total (overall)
Overall food security						
Improved	1 (1%)	121 (100%)	122 (60%)	10 (18%)	135 (92%)	145 (72%)
No effect	0	0	0	11 (20%)	5 (3%)	16 (8%)
Decreased	0	0	0	1 (2%)	3 (2%)	4 (2%)
Unsure	82 (99%)	0	82 (40%)	34 (61%)	3 (2%)	37 (18%)
Total	83	121	204	56	146	202
Health and nutrition						
Improved	1 (1%)	118 (98%)	119 (58%)	19 (34%)	130 (89%)	149 (74%)
No effect	0	3 (2%)	3 (1%)	3 (5%)	11 (8%)	14 (7%)
Decreased	0	0	0	0	2 (1%)	2 (1%)
Unsure	82 (99%)	0	82 (40%)	34 (61%)	3 (2%)	37 (18%)
Total	83	121	204	56	146	202

Source: Survey data
Note: Percentages total to 100% column-wise. Due to rounding, column wise totals will not necessarily equal.

To further understand changes in food security, the number of months food insecure and meals per day were investigated and reported by farmers. After CA implementation, it is found that the difference in number of meals per day between ACT and Non-ACT farmers is statistically significant at all levels. That is, on average, Zimbabwean ACT farmers have a higher number of meals per day than Non-ACT farmers. The difference in number of observations captured for Non-ACT farmers is however notable and more observations would need to be captured for an accurate comparison.

Additionally, the mean number of months food insecure before CA between Zimbabwean Non-ACT and ACT farmers was found to be statistically significant at all significance levels. This means that on average, ACT farmers experienced more months of food security than Non-ACT farmers. Food security is therefore found to be a possible motivation in the adoption of CA. Post CA implementation, the number of months food spent food insecure by Zimbabwean ACT farmers decreased from 4.5 months to 1.1 months.

Table 4.11: Number of meals per day and months food insecure variable outcomes from farmer self-evaluation reports

	KENYA (204 farmers)				ZIMBABWE (202 farmers)			
	Non-ACT	**ACT**	**T-stat**	**P-value**	**Non-ACT**	**ACT**	**Obs.**	**P-value**
Number of meals per day *before* CA								
Mean number of meals	1.80 (0.08)	1.9 (0.43)	-1.47	0.143	2.10 (0.29)	2.2 (0.55)	-0.73	0.466
Number of observations	35	120			22	146		
Number of meals per day *after* CA								
Mean number of meals	--	0.1 (0.28)	--	--	2.2 (0.41)	2.8 (0.42)	-6.06	0.000^{***}
Number of observations	--	119			20	146		
Number of food insecure months *before* CA								
Mean number of months	6.86 (1.10)	6.47 (1.61)	1.37	0.172	1.82 (2.92)	4.47 (3.50)	-3.37	0.001^{***}
Number of observations	36	120			22	144		
Number of food insecure months *after* CA								
Mean number of months	--	0.8	--	--	1.3	1.1	0.28	0.7815
Number of observations	--	119			20	20		

*Source: Survey data; ***Significant at 1% level, **Significant at 5% level, *Significant at 10% level*

4.4.2.2. Income

Income is a major consideration of implementation of farming methods for any farmer. Since the majority of farmers from both countries stated crop production as a major source of income, any impact of CA implementation on income will be an important factor for the promotion of adoption. Table 4.11 shows these results.

After CA implementation by ACT farmers in both countries, we see a majority state an increase in income, especially in Kenya at 86%. In Zimbabwe, only 67% report increased income, while 32% report stagnation and 1% report a decrease. Changes in crop production will only produce perceived income increases, ceteris paribus and it is therefore important to account for other income streams when considering changes in income due to crop production. Still, the majority of ACT Zimbabwean farmers reported increased incomes, which indicates improvements from CA intervention.

Table 4.12: Income related variable outcomes from farmer self-evaluation reports

	KENYA (204 farmers)			ZIMBABWE (202 farmers)		
	Non-ACT (83 obs.)	ACT (121 obs.)	Overall	Non-ACT (56 obs.)	ACT (146 obs.)	Overall
			Overall income			
Increased	1 (1%)	104 (86%)	105 (51%)	17 (30%)	118 (81%)	135 (67%)
Stagnated	0	17 (14%)	17 (8%)	39 (70%)	26 (18%)	65 (32%)
Decreased	0	0	0	0	2 (1%)	2 (1%)
Unsure	82 (99%)	0	82 (40%)	34 (61%)	2 (1%)	36 (18%)
Total	83	121	204	56	146	202
			Product sales value in USD			
Increased	1 (1%)	105 (87%)	106 (51%)	2 (4%)	92 (63%)	94 (47%)
Stagnated	0	7 (6%)	7 (3%)	15 (27%)	35 (24%)	50 (25%)
Decreased	0	0	0	1 (2%)	0	1 (1%)
Unsure	82 (99%)	9 (7%)	92 (45%)	38 (68%)	19 (13%)	57 (28%)
Total	83	121	204	56	146	202
			Total production costs in USD			
Increased	0	6 (5%)	6 (3%)	0	17 (12%)	17 (8%)
Stagnated	0	1 (1%)	1 (1%)	9 (16%)	10 (7%)	19 (9%)
Decreased	0	112 (93%)	112 (55%)	11 (20%)	115 (79%)	126 (62%)
Unsure	83 (100%)	2 (2%)	85 (42%)	36 (64%)	4 (3%)	40 (20%)
Total	83	121	204	56	146	202
			Total profits in USD			
Increased	0	108 (89%)	108 (53%)	6 (11%)	94 (64%)	100 (50%)
Stagnated	0	8 (7%)	8 (4%)	14 (25%)	38 (26%)	52 (26%)
Decreased	0	0	0	1 (2%)	1 (1%)	2 (1%)
Unsure	83 (100%)	5 (4%)	88 (43%)	35 (63%)	13 (9%)	48 (24%)
Total	83	121	204	56	146	202

Source: Survey data
Note: Percentages total to 100% column-wise. Due to rounding, column wise totals will not necessarily equal.

A reliable income is an important element of improved livelihood and will increase the likelihood of adoption amongst farmers (Chiputwa, Langyintuo et al. 2010 {Kunzekweguta, 2017 #28)}. Increased reliability of income is also more likely to enable farmers to spread the benefits of the CA technology in the community through knock-on effects of expenditure and consumption from the higher disposable income from the farmer. The income reliability is therefore investigated, and the results shown in Table 4.13.

Access to assets is also an important determinant of improved livelihoods and is categorised in this study as the ability to source credit and save capital. ACT farmers in Kenya and Zimbabwe were asked to cite the changes in their ability to source credit and have savings before and after CA. Access to assets and the ability to accrue savings can help reduce barriers to entry in the adoption of CA such as capital investments in equipment, inputs for production, and the ability to grow income for long term poverty reduction (Ndiritu et al., 2014). Table 4.14 shows the access to credit for ACT and Non-ACT farmers in Kenya and Zimbabwe and the factors contributing to or inhibiting access.

Table 4.13: Income reliability as self-reported by farmers

	KENYA (204 farmers)			ZIMBABWE (202 farmers)		
	Non-ACT (83 obs.)	ACT (121 obs.)	Overall	Non-ACT (56 obs.)	ACT (146 obs.)	Overall
How reliable is income obtained from the CA project enterprise?						
Very reliable	4 (5%)	119 (98%)	123 (60%)	0	53 (36%)	53 (26%)
Somehow reliable	0	0	0	3 (5%)	76 (52%)	79 (39%)
Less reliable	0	0	0	7 (13%)	8 (5%)	15 (7%)
Not reliable at all	0	0	0	11 (20%)	8 (5%)	19 (9%)
Unsure	79 (95%)	2 (2%)	81 (40%)	35 (63%)	1 (1%)	36 (18%)
Total	83	121	204	56	146	164

Source: Survey data
Note: Percentages total to 100% column-wise. Due to rounding, column wise totals will not necessarily equal.

In both countries, ACT farmers consistently cite more access to credit than Non-ACT farmers. However, the difference in Zimbabwe is marginal, with only 5% of ACT farmers gaining access to assets, compared to the 92% that cite no previous credit access. To further break down the credit opportunities of farmers in both countries, the distance to the nearest financial institution was compared for Non-ACT and ACT farmers, as well as the average value in US dollars. Table 4.15 shows these results as per findings.

Table 4.14: Access to credit variable outcomes from farmer self-evaluation reports

	KENYA (204 farmers)			ZIMBABWE (202 farmers)		
	Non-ACT (83 obs.)	ACT (121 obs.)	Overall	Non-ACT (56 obs.)	ACT (146 obs.)	Overall
Have you ever accessed credit?						
No	61 (73%)	44 (36%)	105 (51%)	22 (39%)	134 (92%)	156 (95%)
Yes	22 (27%)	77 (64%)	99 (49%)	0	8 (5%)	8 (5%)
Total	83	121	204	22	142	164
Reasons for previous access to credit						
Agricultural production	14 (45%)	57 (54%)	77 (54%)	0	7 (88%)	7 (88%)
Health/domestic issues	13 (42%)	32 (30%)	45 (31%)	0	0	0
Construction investments	2 (6%)	6 (6%)	9 (6%)	0	1 (12%)	1 (12%)
Running of business	2 (6%)	3 (3%)	5 (4%)	0	0	0
Other	0 (0%)	7 (7%)	7 (5%)	0	0	0
Total	31	105	136	0	8	8
Reasons for previous lack of access to credit						
Fear or risk averseness	43 (47%)	26 (43%)	69 (45%)	13 (50%)	49 (50%)	62 (38%)
Lack of awareness	10 (11%)	8 (13%)	18 (12%)	9 (35%)	67 (35%)	76 (46%)
High interest rates	39 (42%)	18 (30%)	57 (38%)	2 (8%)	11 (8%)	13 (8%)
Other	0 (0%)	8 (13%)	8 (5%)	2 (8%)	12 (8%)	14 (8%)
Total	92	60	152	26	139	165

Source: Survey data
Note: Percentages total to 100% column-wise; Reasons cited can be multiple, and column wise totals will not necessarily equal.

Using the p-values, we do not reject the null hypothesis of the equality of all means for Non-ACT and ACT farmers in Table 4.15. That is, on average, the difference in distance to the nearest financial institutions for Non-ACT and ACT farmers in both countries is not statistically significant. This is also true for the mean value of credit previously accessed for both farmer groups in Kenya. In Zimbabwe, a lack of observations for Non-ACT farmers meant a comparison of means could not be performed. Please refer to the appendix for further insight on the sources of credit for farmers in both countries.

Table 4.15: Mean distance of nearest financial institutions and of credit value provided in Kenya and Zimbabwe.

	KENYA (204 farmers)			**ZIMBABWE (202 farmers)**		
	Non-ACT (83 obs.)	**ACT (121 obs.)**	**P-value**	**Non-ACT (56 obs.)**	**ACT (146 obs.)**	**P-value**
Mean distance of nearest financial institution (kilometres, **km)**	20.33	17.89	0.1815	33.34	36.01	0.5308
Mean value of credit accessed (USD)	478.64	597.27	0.5446	0	233.875	--

Source: Survey data

4.4.3. Social dynamics and gender disparity

Social cohesion was investigated by asking farmers to indicate if the solidarity, social cohesion and group work amongst them increased, decreased or stagnated. The results obtained will be used as another outcome variable that informs the impact of CA adoption and can increase the likelihood of adoption. Farm workload effects on gender are the majority of ways in which gender disparity in agriculture can be reduced. Ndiritu et al. (2014) outlined various gender disparities for small scale farmers such as ownership of land, especially land with more fertile soils, number of livestock owned, labour capabilities and access to credit from financial institutions. In testing the adoption practices of sustainable agricultural practices, it was found that “female plot managers were less likely to adopt minimum tillage and manure for soil fertility management compared with male lot managers” (Ndiritu et al., 2014:125). Considering this, the outcome variables identified from the questionnaire are are decreased farm workload and overall gender disparity as observed on a self-evaluation basis. Tables 4.16 and 4.17 show the social dynamics and gender disparity self-evaluation reports that informed the chosen outcome variables.

Table 4.16: Social dynamics related variable outcomes from farmer self-evaluation reports

	KENYA (204 farmers)			ZIMBABWE (202 farmers)		
	Non-ACT (83 obs.)	ACT (121 obs.)	Overall	Non-ACT (56 obs.)	ACT (146 obs.)	Overall
Farmers who attended the group dynamics CA training						
Yes	15 (25%)	57 (60%)	72 (47%)	12 (22%)	1 (5%)	13 (17%)
No	44 (75%)	38 (40%)	82 (53%)	43 (78%)	20 (95%)	63 (83%)
Total	59	95	154	55	21	76
Farmers who used the group dynamics skills gained through CA training						
Used skills	13 (36%)	57 (84%)	75 (60%)	6 (15%)	1 (5%)	7 (12%)
Did not use skills	23 (64%)	11 (16%)	49 (40%)	33 (85%)	20 (95%)	53 (88%)
Total	36	68	124	39	21	60
Solidarity, social cohesion, and group work before CA						
High	0 (0%)	1 (1%)	1 (1%)	7 (33%)	5 (4%)	12 (7%)
Low	1 (100%)	117 (99%)	118 (99%)	14 (67%)	137 (96%)	151 (93%)
Total	1	118	119	21	142	163
Solidarity, social cohesion, and group work *after* CA						
Increased	1 (100%)	118 (99%)	119 (99%)	11 (52%)	135 (95%)	146 (90%)
Stagnated	0	1 (1%)	1 (1%)	6 (29%)	7 (5%)	13 (8%)
Decreased	0	0 (0%)	0 (0.00%)	4 (19%)	0	4 (2%)
Total	1	119	120	21	142	163

Source: Survey data
Note: Percentages total to 100% column-wise. Due to rounding, column wise totals will not necessarily equal.

Table 4.17: Gender disparity related variable outcomes from farmer self-evaluation reports

	KENYA (204 farmers)			ZIMBABWE (202 farmers)		
	Non-ACT (83 obs.)	ACT (121 obs.)	Overall	Non-ACT (56 obs.)	ACT (146 obs.)	Overall
Has CA reduced labour and agricultural workload?						
No	81 (98%)	22 (18%)	103 (50%)	53 (95%)	61 (42%)	114 (56%)
Yes	2 (2%)	99 (82%)	101 (509%)	3 (5%)	85 (58%)	88 (44%)
Total	83	121	204	56	146	202
If YES, whose labour is reduced?						
Both	0	36 (36%)	36 (36%)	3 (100%)	50 (59%)	53 (60%)
Female	1 (1%)	63 (64%)	64 (63%)	0	33 (39%)	33 (38%)
Male	0	0	0	0	1 (1%)	1 (1%)
No change	1 (50%)	0	1 (1%)	0	1 (1%)	1 (1%)
Total	2	99	101	3	85	88
Overall perceived changes in gender disparity						
Improved	0	119 (98%)	119 (58%)	4 (18%)	85 (59%)	89 (44%)
Stagnant	83 (100%)	2 (2%)	85 (42%)	27 (55%)	46 (17%)	73 (36%)
Decreased	0	0	0	6 (27%)	34 (24%)	40 (20%)
Total	83	121	204	56	146	202
Timeline impacts and realisations on perceived changes in gender disparity						
Short term	0	34 (28%)	34 (28%)	1 (2%)	54 (36%)	55 (27%)
Medium term	1 (1%)	14 (12%)	15 (7%)	9 (16%)	42 (29%)	51 (25%)
Long term	0	4 (3%)	1 (3%)	10 (18%)	41 (28%)	51 (25%)
Unsure	82 (99%)	69 (57%)	151 (74%)	36 (64%)	9 (6%)	45 (22%)
Total	83	121	204	56	146	202

Source: Survey data
Note: Percentages total to 100% column-wise. Due to rounding, column wise totals will not necessarily equal.

Kenyan and Zimbabwean ACT farmers reported reduced farm workload as a majority (83% and 61% respectively). In Zimbabwe, the majority of observed workload reduction is reported for both male and female farmers while Kenyan farmers report workload reduction to primarily favour females. This implies that the farm workload techniques may be more labour intensive and therefore CA adoption would result in significant changes. Additionally, Kenyan farming households are majority male led, with 66% of ACT farming households being male led – this indicates a gender gap in the Kenyan farming sector relative to Zimbabwe.

4.4.4. Sustainability and environmental practices

CA adoption is reported to positively affect ecosystem services and the natural environment e.g. through reduced water runoff from permanent soil cover and surface crusting, increased aggregate stability and water infiltration, greater total water supply and water use efficiency (Palm et al., 2014). The survey investigated the effects of CA adoption from this sample population and identified the amount of forest area cleared per year in hectares and the changes in soil health as environmental change outcomes. Farmers indicated whether the forest area cleared per year and soil fertility increased, decreased, or stagnated after CA intervention, in both countries.

Forest area cleared per year after CA is reported to have increased in Kenya. There are two possibilities to these results. First, there may have possible been a miscommunication between the farmer and the data capture where the farmer was under the impression that decreased forest area is a positive benefit. The second option is that forest area cleared in hectares was increased due to the increased need for mulching or soil cover given the techniques of CA. In Zimbabwe, the forest area cleared in hectares is reported to have either stayed constant or decreased, which is clear sustainable practices and environmental benefit for farmers.

Table 4.18: Sustainability and environmental practices variable outcomes from farmer self-evaluation reports

	KENYA (204 farmers)			ZIMBABWE (202 farmers)		
	Non-ACT (83 obs.)	ACT (121 obs.)	Overall	Non-ACT (56 obs.)	ACT (146 obs.)	Overall
Forest area cleared per year *before* CA						
High	0	1 (1%)	1 (1%)	6 (11%)	53 (36%)	59 (29%)
Low	1 (1%)	118 (98%)	119 (58%)	15 (27%)	89 (61%)	104 (51%)
Unsure	82 (99%)	2 (2%)	84 (41%)	35 (63%)	4 (3%)	39 (19%)
Total	83	121	204	56	146	202
Forest area cleared per year *after* CA						
Increased	1 (1%)	90 (74%)	91 (45%)	0	2 (1%)	2 (1%)
Stagnated	0	28 (23%)	28 (14%)	18 (32%)	94 (64%)	112 (55%)
Decreased	0	1 (1%)	1 (1%)	3 (5%)	45 (31%)	48 (24%)
Unsure	82 (99%)	2 (2%)	84 (41%)	35 (63%)	5 (3%)	40 (20%)
Total	83	121	204	56	146	202
Adaptation						
Increased	1 (1%)	119 (99%)	120 (59%)	5 (9%)	98 (67%)	103 (51%)
Stagnated	0	0	0	14 (25%)	44 (30%)	58 (29%)
Decreased	0	0	0	3 (5%)	1 (1%)	4 (2%)
Unsure	82 (99%)	2 (1%)	84 (41%)	34 (61%)	3 (2%)	37 (18%)
Total	83	121	204	56	146	202
Drought resilience						
Increased	1 (1%)	119 (99%)	120 (59%)	5 (9%)	117 (80%)	122 (60%)
Stagnated	0	0	0	13 (23%)	26 (18%)	39 (19%)
Decreased	0	0	0	4 (7%)	0	4 (2%)
Unsure	82 (99%)	2 (1%)	84 (41%)	34 (61%)	3 (2%)	37 (18%)
Total	83	121	204	56	146	202

Source: Survey data

Note: Percentages total to 100% column-wise. Due to rounding, column wise totals will not necessarily equal.

4.4.5. Differences between impact on ACT and non-ACT farmers

To begin an assessment of the difference in impacts of CA implementation, the number of outcome variables that were indicated to have improved, stagnated and decreased were collected. The timeline of impacts of reported outcomes of some outcome variables was also examined and reported. The following sections will show the categorisation of outcome variables as cited by farmers in the survey. Furthermore, the difference between the proportion of Non-ACT and ACT farmers will be provided to provide an indication of the experiences of impacts between both farmer groups.

4.4.5.1. Improved outcomes as cited by survey respondents

The outcome variables that were reported to have improved or increased are summarised in the table below, with the difference between the ACT and Non-ACT farmers provided. Rank order shows the most improved to least improved variable outcomes. Differences in reported outcomes shows the varied impact of CA on variable outcomes between the control groups as self-reported by farmers. The larger the difference, the larger the observed impact of CA in adopted versus non-adopted farmer households.

Tables 4.19 and 4.20 imply that there are more ACT farmers in Kenya who report increases in the outcome variables than in Zimbabwe. The top 12 variable outcomes show differences of 73% and above, relative to the Zimbabwean outcome variables, which show differences from 51% and above. Interestingly, food security is reported as a high ranking improved outcome, ranking number 1 in Kenya and number 3 in Zimbabwe in terms of differences reported in effects. Costs in USD is a lower ranking variable, showing minimal difference in increases and ranking 15 in Kenya and 14 in Zimbabwe. This implies that cost impacts were clearly and distinctly felt by CA farmers in both farmers and increased costs were not a significant issue for the CA farmers.

Table 4.19: Rank order of improved outcomes in Kenya

	Outcome variable	KENYA		
		Non-ACT (83 obs.)	**ACT (121 obs.)**	**Difference**
1.	**Food security**	0	118 (98%)	98%
2.	**Gender disparity**	0	119 (98%)	98%
3.	**Health and nutrition**	1 (1%)	118 (98%)	97%
4.	**Agricultural bottlenecks**	1 (1%)	119 (98%)	97%
5.	**Adaptation**	1 (1%)	119 (98%)	97%
6.	**Agricultural yield**	1 (1%)	119 (98%)	97%
7.	**Drought resilience**	1 (1%)	119 (98%)	97%
8.	**Soil fertility**	1 (1%)	117 (97%)	96%
9.	**Savings capacity**	0	116 (96%)	96%
10.	**Solidarity, social cohesion and group work**	1 (1%)	116 (96%)	95%
11.	**Profits in USD**	0	108 (89%)	89%
12.	**Product sales in USD**	0	105 (87%)	87%
13.	**Forest area cleared per year (hectares)**	1 (1%)	89 (74%)	73%
14.	**Access to credit**	0	59 (49%)	49%
15.	**Costs in USD**	0	6 (5%)	5%

Source: Survey data
Note: The difference is between ACT and Non-ACT farmers

Table 4.20: Rank order of improved outcomes in Zimbabwe

	Outcome variable	ZIMBABWE			Rank order and difference relative to Kenya
		Non-ACT (56 obs.)	ACT (146 obs.)	Difference	
1.	**Agricultural yield**	7 (12%)	139 (95%)	83%	6 (97%)
2.	**Soil fertility**	7 (13%)	137 (94%)	81%	8 (96%)
3.	**Food security**	9 (16%)	137 (94%)	78%	1 (98%)
4.	**Solidarity, social cohesion, and group work**	11 (20%)	141 (96%)	76%	10 (95%)
5.	**Drought resilience**	5 (9%)	117 (80%)	71%	7 (97%)
6.	**Product sales in USD**	2 (3%)	92 (63%)	60%	12 (87%)
7.	**Adaptation**	5 (9%)	98 (67%)	58%	5 (97%)
8.	**Forest area cleared per year (hectares)**	2 (4%)	88 (60%)	56%	13 (73%)
9.	**Health and nutrition**	19 (34%)	130 (89%)	55%	3 (97%)
10.	**Profits in USD**	6 (11%)	94 (64%)	53%	11 (89%)
11.	**Agricultural bottlenecks**	5 (9%)	90 (62%)	53%	4 (97%)
12.	**Gender disparity**	4 (7%)	85 (58%)	51%	2 (98%)
13.	**Savings capacity**	3 (5%)	74 (51%)	46%	9 (96%)
14.	**Costs in USD**	0	17 (11%)	11%	15 (5%)
15.	**Access to credit**	0	5 (3%)	3%	14 (49%)

Source: Survey data
Note: The difference is between ACT and Non-ACT farmers

4.4.5.2. Stagnated outcomes as cited by survey respondents

The following outcomes were reported to be stagnant after the adoption of CA. Stagnation in this study is defined as an observation of no changes in the variables outcomes as reported by farmers. Rank order shows the most stagnant to least stagnant variable outcomes. The larger the difference, the greater the lack of impact on variable outcomes between the control groups as self-reported by farmers.

Table 4.21: Rank order of stagnated outcomes in Kenya

		KENYA		
	Outcome variable	**Non-ACT (83 obs.)**	**ACT (121 obs.)**	**Difference**
1.	**Access to credit**	0	31 (25%)	25%
2.	**Forest area cleared per year (hectares)**	0	28 (23%)	23%
3.	**Profits in USD**	0	8 (7%)	7%
4.	**Product sales in USD**	0	6 (5%)	5%
5.	**Health and nutrition**	0	3 (2%)	2%
6.	**Costs in USD**	0	1 (1%)	1%
7.	**Gender disparity**	0	1 (1%)	1%
8.	**Solidarity, social cohesion, and group work**	0	1 (1%)	1%

Source: Survey data
Note: The difference is between ACT and Non-ACT farmers.

Table 4.22: Rank order of stagnated outcomes in Zimbabwe

		ZIMBABWE		
	Outcome variable	**Non-ACT (56 obs.)**	**ACT (146 obs.)**	**Difference**
1.	**Agricultural yield**	13 (23%)	3 (2%)	-21%
2.	**Soil fertility**	13 (23%)	5 (3%)	-20%
3.	**Food security**	11 (20%)	4 (3%)	-17%
4.	**Solidarity, social cohesion, and group work**	6 (11%)	1 (1%)	-10%
5.	**Costs in USD**	9 (16%)	10 (7%)	-9%
6.	**Drought resilience**	13 (23%)	26 (18%)	-5%
7.	**Gender disparity**	12 (21%)	25 (17%)	-4%
8.	**Product sales in USD**	15 (27%)	35 (24%)	-3%
9.	**Access to credit**	20 (36%)	74 (51%)	15%
10.	**Agricultural bottlenecks**	11 (19%)	38 (26%)	7%
11.	**Savings capacity**	17 (30%)	55 (37%)	7%
12.	**Adaptation**	14 (25%)	44 (30%)	5%
13.	**Health and nutrition**	3 (5%)	11 (8%)	3%
14.	**Forest area cleared per year (hectares)**	19 (34%)	52 (36%)	2%
15.	**Profits in USD**	14 (25%)	38 (26%)	1%

Source: Survey data
Note: The difference is between ACT and Non-ACT farmers. Negative differences indicate that less ACT farmers report stagnation of a specific outcome variable than Non-ACT farmers

4.4.5.3. Decreased outcomes as cited by survey respondents

There are a greater number of decreased outcomes reported by Zimbabwean Non-ACT farmers, relative to Kenyan farmers. Most notable, costs in USD are ranked top in both countries as CA impacts on ACT farmers shows a clear reported decreased cost pressure for treated farmers. The number of limited decreased outcome in Kenya is a positive sign of CA impact in farmer livelihoods. However, it can also mean that Kenyan farmers may have been self-selected to have been the poorest compared to Zimbabwean farmers and any form of intervention would have then likely led to exponential changes in the farmer livelihoods.

Table 4.23: Rank order of decreased outcomes in Kenya

	Outcome variable	KENYA		
		Non-ACT (56 obs.)	ACT (146 obs.)	Difference
1.	**Costs in USD**	0	112 (92%)	92%
2.	**Access to credit**	0	19 (16%)	16%
3.	**Forest area cleared per year (hectares)**	0	2 (1%)	1%

Source: Survey data
Note: The difference is between ACT and Non-ACT farmers.

Table 4.24: Rank order of decreased outcomes in Zimbabwe

	Outcome variable	ZIMBABWE		
		Non-ACT (56 obs.)	ACT (146 obs.)	Difference
1.	**Costs in USD**	11 (20%)	115 (79%)	59%
2.	**Forest area cleared per year (hectares)**	2 (4%)	88 (60%)	56%
3.	**Gender disparity**	6 (11%)	34 (23%)	12%
4.	**Health and nutrition**	0	2 (1%)	1%
5.	**Adaptation**	4 (7%)	0	-7%
6.	**Solidarity, social cohesion, and group work**	4 (7%)	0	-7%
7.	**Bottlenecks**	12 (21%)	25 (17%)	-4%
8.	**Agricultural yield**	2 (4%)	1 (1%)	-3%
9.	**Product sales *after* CA (USD)**	2 (4%)	2 (1%)	-3%
10.	**Product sales in USD**	1 (2%)	0	-2%
11.	**Soil fertility**	1 (2%)	0	-2%
12.	**Drought resilience**	6 (11%)	15 (10%)	-1%
13.	**Profits in USD**	1 (2%)	1 (1%)	-1%
14.	**Food security**	1 (2%)	0	-2%

Source: Survey data
Note: The difference is between ACT and Non-ACT farmers. Negative differences indicate that less ACT farmers report a decrease in a specific outcome variable than Non-ACT farmers

4.4.6. Impact timelines

The following variable outcomes were reported to change in specific timelines. Table 4.25 shows the timelines of impacts as reported by farmers in the survey.

Food security is reported by Kenyan farmers to demonstrate long terms impacts whereas Zimbabwean farmers cite short term impacts from food security. Gender disparity and environmental impacts are cited as more short term and medium term in both Kenya and Zimbabwe, which may pose as a challenge given the nature of the outcomes. Long term environmental impact will support sustainability and future productivity for farmers, as well as improved long term soil health. Gender disparity should display long term structural changes in inequities in labour and income between the genders and short term impacts do not lend to institutional changes in gender disparity (Food and Agriculture Organisation of the United Nations 2011, Ndiritu, Kassie et al. 2014).

Table 4.25: Timeline impacts of variable outcomes as self-reported by farmers

	KENYA			ZIMBABWE		
Outcome variable	**Non-ACT (83 obs.)**	**ACT (121 obs.)**	**Difference**	**Non-ACT (56 obs.**	**ACT (146 obs.)**	**Difference**
Short term impacts						
Food security impacts	0	1 (1%)	1%	14 (25%)	110 (75%)	50%
Solidarity, social cohesion and group work	0	36 (30%)	30%	5 (9%)	52 (36%)	27%
Environmental impacts	0	4 (3%)	3%	3 (6%)	43 (29%)	23%
Health and nutrition impacts	0	0	0	3 (6%)	28 (19%)	13%
Gender disparity impacts	0	34 (28%)	28%	54 (37%)	1 (2%)	-35%
Medium term impacts						
Health and nutrition impacts	0	9 (7%)	7%	9 (16%)	91 (62%)	46%
Solidarity, social cohesion and group work	1 (1%)	15 (12%)	11%	10 (18%)	55 (38%)	20%
Environmental impacts	1 (1%)	39 (32%)	31%	9 (16%)	51 (35%)	19%
Food security impacts	0	9 (7%)	7%	5 (9%)	27 (19%)	10%
Gender disparity impacts	1 (1%)	14 (12%)	11%	42 (29%)	9 (16%)	-13%
Long term impacts						
Food security impacts	1 (1%)	50 (41%)	40%	1 (2%)	5 (3%)	1%
Health and nutrition impacts	1 (1%)	48 (40%)	39%	8 (14%)	16 (11%)	-3%
Gender disparity impacts	0	4 (3%)	3%	41 (28%)	10 (18%)	-10%
Environmental impacts	0	11 (9%)	9%	8 (14%)	41 (28%)	14%
Solidarity, social cohesion and group work	0	2 (2%)	2%	5 (9%)	31 (21%)	12%

Source: Survey data
Note: The difference is between ACT and Non-ACT farmers. Negative differences indicate that less ACT farmers report decrease of a specific outcome variable than Non-ACT farmers

4.5. Assessment based on propensity score matching

In addition to the assessment of reflexive controls, an impact assessment was conducted using propensity score matching techniques. Propensity Score Matching (PSM) is used when there is evidence of self-selection bias and a non-random process of assignment of treatment. To test for self-selection bias, a t-test/chi-squared test on the means of covariates that determine treatment was conducted (t-tests were used for discrete variables and a chi-square test for categorical variables). A statistically significant difference in the means of the farming households indicates that the characteristics of ACT versus Non-ACT farmers when tested by treatment could lead to self-selection bias. Table 4.26 shows these results.

Table 4.26: T-test of covariates by treatment variables for individual countries

	KENYA			ZIMBABWE		
COVARIATES	**Non-ACT (83 obs.)**	**ACT (121 obs.)**	**P-value**	**Non-ACT (56 obs.)**	**ACT (146 obs.)**	**P-value**
Mean age of household head (years)	56.36	56.26	0.9449	49.46	54.00	0.0502*
Dummy variable for gender (0 = Female, 1 = Male)	0.675	0.661	0.8412	.6071	0.500	0.1737
Education of household head (Dummy, 0 = No formal education)	1.24	1.57	0.0021***	1.42	1.36	0.5509
Beneficiary of previous CA project (0 = No, 1 = Yes)	0.614	0.909	0.000***	0.179	0.545	0.000***
Previous access to credit (0 = No, 1 = Yes)	0.265	0.636	0.000***	0.00	0.056	0.2564
Awareness of CA activities in village or nearby villages (0 = No, 1 = Yes)	0.458	0.595	0.0538*	0.822	0.817	0.9362

*Source: Survey data; ***Significant at 1% level, **Significant at 5% level, *Significant at 10% level*

The difference of means tests for Kenya are statistically significant for all covariates except for age and gender of the household head. This shows evidence of selection bias, where a Kenyan farmer with more education, a previous CA beneficiary, a farmer with previous access to credit or with awareness of CA activities in the village was more likely to adopt CA. In Zimbabwe, evidence for self-selection bias for treatment is statistically significant for only older farmer household heads who are educated, and those who were previous CA beneficiaries. To investigate the possibility of selection bias at the macro level, the difference in means tests were also conducted with the stacked level data for both Kenya and Zimbabwe and Table 4.27 shows these results. Interaction terms were also added to investigate the impact of the compounded factors that may better explain the covariates that most affect farmers characteristics that lend to selection bias.

On average, ACT farmers who were more educated in both Kenya and Zimbabwe were more likely to choose treatment. Similarly, farmers who had participated in a previous CA project, had previous access to credit and were aware of CA related activities in the village or nearby villages, were more likely to choose to adopt CA in both countries. Zimbabwean farmers who had a primary education or had been previous CA project beneficiaries were significantly different to their Kenyan counterparts at all levels.

Table 4.27: Difference in means test for covariates by treatment variable for both Kenya and Zimbabwe using stacked data

	KENYA & ZIMBABWE		
COVARIATES	**Non-ACT (139 obs)**	**ACT (267 obs)**	**P-value**
Mean age of household head (years)	53.58	55.02	0.2889
Dummy variable for gender (0 = Female, 1 = Male)	0.647	0.573	0.146
Education of household head (Dummy, 0 = No formal education)	1.317	1.457	0.025***
Beneficiary of previous CA project (0 = No, 1 = Yes)	0.439	0.712	0.000***
Previous access to credit (0 = No, 1 = Yes)	0.210	0.323	0.030**
Awareness of CA activities in village or nearby villages (0 = No, 1 = Yes)	0.591	0.715	0.014**
Country*Household head gender (1 = Zimbabwean male farmer, 0 = otherwise)	0.245	0.273	0.532
Country*Primary education (1 = Zimbabwean farmer with primary school education, 0 = otherwise)	0.115	0.277	0.002***
Country*Previous CA project beneficiary (1 = Zimbabwean farmer who previously participated in CA project, 0 = otherwise)	0.072	0.300	0.000***

*Source: Survey data; ***Significant at 1% level, **Significant at 5% level, *Significant at 10% level*

Given this evidence, the balancing property was approximated using a probit model. The first stage regression shown in Table 4.28 satisfies the balancing property and approximates the treatment variable given the covariates that best determine treatment. The controls chosen are informed by literature such as Mango et al. (2017) and Lalani et al. (2017). Other conditional covariates such as soil fertility and total area of land in hectares were tested for the model as per Ndah et al. (2015), Pedzisa et al. (2015) and Van Hulst and Posthumus (2016), however they were found to be insignificant in this study's model.

Table 4.28: First stage probit regression for propensity score matching

Covariates	**Participation in CA (Yes = ACT or No = Non-ACT)**	
	Coef.	***p-value***
Household head age	0.009	0.291
Household head gender (0 = Female, 1 = Male)	-0.309	0.203
Household Head Education (Dummy, 0 = No formal education)		
Primary	0.475	0.144
Secondary	0.942	0.002***
University/College	1.255	0.023**
Beneficiary of previous CA project (0 = No, 1 = Yes)	1.237	0.000***
Previous access to credit (0 = No, 1 = Yes)	1.012	0.000***
Aware of CA activities in village or nearby villages (0 = No, 1 = Yes)	0.553	0.002***
Country (0 = Kenya, 1 = Zimbabwe)	2.373	0.000***
Country*Household head gender (1 = Zimbabwean male farmer, 0 = otherwise)	-0.685	0.081*
Country*Primary education (1 = Zimbabwean farmer with primary school education, 0 = otherwise)	0.756	0.044**
Country*Previous CA project beneficiary (1 = Zimbabwean farmer who previously participated in CA project, 0 = otherwise)	-1.259	0.001***
Constant	-2.414	0.000***
Statistics		
Observations	366	
Log likelihood	-156.83	
Wald Chi square	123.23	
Prob > chisq	0.0000***	
Pseudo R^2	0.2821	

*Source: Survey data; ***Significant at 1% level, **Significant at 5% level, *Significant at 10% level*

The interaction terms for the countries show that male Zimbabwean farmers were less likely to adopt CA compared to other household heads (significant at the 10% level). This has implications on the policy implementation of the program, where male Zimbabwean farmers would need to be targeted disproportionately more to drive adoption for them. Zimbabwean farmers with a primary school education were more likely to choose treatment, significant at the 5% level. This implies that primary education in Zimbabwe is the bigger influencer for treatment as compared to Non-ACT farmers in Zimbabwe and overall farmers in Kenya.

Previous beneficiaries of CA projects at the aggregate level had a higher probability of adopting CA at all significant levels. However, the interaction term for previous CA project beneficiary by country shows that Zimbabwean farmers who were previous CA beneficiaries were less likely to participate in treatment at all levels. This has implications for adoption policies in

Zimbabwe - previous or current CA related projects need to be evaluated and/or previous participants interviewed. It is important to identify the reasons for disadoption, which may include factors such as unobserved benefits, increased opportunity costs, and increased farming constraints.

The propensity scores (pscores) for treated and control values and the balancing property were satisfied using the probit model above. The pscores for ACT and Non-ACT farmers were compared using the using the following null hypothesis. Table 4.29 shows the results.

H_0: The difference in the mean propensity scores for ACT and for Non-ACT farmers is 0

Table 4.29: Two sample t-test for equality of propensity score means of farmer groups

	Mean	Std. Dev.	Std. Error	T-stat	DF	P-value
ACT farmers	0.795	0.251	0.025	-12.08	364	0.000***
Non-ACT farmers	0.512	0.180	0.011			

*Source: Survey data; ***Significant at the 1% level*

The null hypothesis is rejected at all significance levels, meaning that there is a significant difference in the distributions of the pscores for the two farmer groups. As expected, farmers who participated in ACT show higher pscores for treatment, with their distribution being skewed to the right, while Non-ACT farmers show lower pscores, with their distribution showing the highest density around a probability of 0.5.

A two sample t-test was also conducted for the pscore distributions of Kenyan and Zimbabwean farmers. The findings also indicate a non-equality of means, with the following null hypothesis being tested. Table 4.30 shows the results of the test.

H_0: The difference between the mean propensity scores for Kenyan and Zimbabwean farmers is equal to 0

Table 4.30: Two sample t-test for propensity score means of Kenyan and Zimbabwean farmers

	Mean	Std. Dev.	Std. Error	T-stat	DF	P-value
Kenya	0.597	0.248	0.017	-12.53	364	0.000***
Zimbabwe	0.862	0.117	0.009			

*Source: Survey data; ***Significant at the 1% level*

Using the t-test p-value we reject the null hypothesis above at all significance levels. This indicates that the distribution of the pscores between Kenya and Zimbabwe are not equal. The results imply that Zimbabwean farmers have higher propensity scores and are therefore more likely to self-choose treatment compared to Kenyan farmers. This corresponds to the country dummy variable with a coefficient of 2.373 in Table 4.28 – Zimbabwean farmers were twice as likely to take part in treatment. Reasons for this may possibly include the dire economic situation of the country and the high input and labour constraints. Additionally, reduced tillage farming practices have been promoted in the region for a longer period of time than Kenya, with reports of CA projects as early as 1965 in what was then named Southern Rhodesia (Andersson and Giller, 2012).

4.5.1. The average treatment effect on the variables studied

Average Treatment Effects (ATT) in propensity score matching indicate the average effect of a treatment on a specific outcome variable, given a set of categorical variables. In this study, unless otherwise indicated, the variables of study are categorical variables with two categories (1 = increased, 0 = stagnated or -1 = decreased). The ATT will represent the average difference in the outcome variable between the ACT farmers and the Non-ACT. Therefore, the ATT would then provide an estimate of the average changes in the outcome variable that can be attributed to the adoption of CA, compared to the non-adoption of CA. A positive ATT indicates that, on average, adoption of CA resulted in an increase in the outcome variable compared to non-adoption. Conversely, a negative ATT suggests that, on average, adoption of CA led to a stagnation or decrease in the outcome variable compared to non adoption

4.5.2. The impact of CA on production

The effect of CA on farm yield is positive and statistically significant in both Kenya and Zimbabwe. These results are shown in Table 4.31. Farmers reported the biggest increase in maize and beans production and the smallest in sorghum production. This may be because maize and beans were the primary crops grown in the geographies of study. All results were statistically significant except for the ATTs in Zimbabwe for beans production using nearest neighbour matching and sorghum production using nearest neighbour and kernel matching.

Table 4.31: Impact of CA Adoption on yield variables for Kenya and Zimbabwe

	KENYA		ZIMBABWE	
	ATT.(Std. Error)	T-stat	ATT. (Std Error)	T-stat
Farm Yield				
Nearest Neighbour Matching	0.983(0.012)	84.499***	0.871(0.237)	3.679***
Kernel Matching	0.983(0.009)	111.484***	0.812(0.082)	9.931***
Maize production				
Nearest Neighbour Matching	0.967(0.016)	59.245***	0.736(0.223)	3.299***
Kernel Matching	0.967(0.014)	70.072***	0.819(0.125)	6.577***
Beans production				
Nearest Neighbour Matching	0.926(0.024)	38.644***	0.286(0.192)	1.490
Kernel Matching	0.926(0.020)	45.564***	0.268(0.127)	2.107**
Sorghum production				
Nearest Neighbour Matching	0.091(0.029)	3.162***	0.014(0.097)	0.147
Kernel Matching	0.091(0.091)	3.488***	0.011(0.045)	0.239

*Source: Survey data; ***Significant at 1% level, **Significant at 5% level, *Significant at 10% level*

4.5.3. The impact of CA on food security and income

The effect on treatment on food security is positive across all chosen variables i.e., self-reflective food security and health and nutrition, as well as the number of meals per day and the number of months food insecure. That is, on average, ACT farmers were more likely to report improvement in food security compared to Non-ACT farmers.

The change in number of meals per day was calculated by differencing the reported number of meals per day before CA and the reported number of meals per day after CA. Farmers who participated in treatment were more likely to experience an increase of one or more meals per day. These findings are statistically significant at all levels. Similarly, on average, ACT farmers experienced approximately 4 months less spent food insecure compared to Non-ACT farmers. Thus, it is concluded that the increased health and nutrition is highly likely to increased given CA adoption due to the reported increases in yield, and subsequent availability of food. To support these findings, farmers also cited increased yields and production of crops as the primary reason for increased food security, please refer to Table A.6 in the appendix for the comprehensive results.

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Table 4.32: Impact of CA Adoption on income variables for Kenya and Zimbabwe

	KENYA		ZIMBABWE	
	ATT.(Std error)	**T-stat**	**ATT.(Std error)**	**T-stat**
Income				
Nearest Neighbour Matching	0.826(0.056)	14.722***	0.264(0.177)	1.493
Kernel Matching	0.854(0.030)	28.721***	0.174(0.150)	1.158
Sales of produce				
Nearest Neighbour Matching	0.868(0.031)	28.062***	0.636(0.173)	3.665***
Kernel Matching	0.868(0.025)	34.805***	0.610(0.084)	7.290***
Profit from produce				
Nearest Neighbour Matching	0.893(0.028)	31.574***	0.514(0.213)	2.420**
Kernel Matching	0.893(0.023)	38.674***	0.513(0.086)	5.950***
Costs of production				
Nearest Neighbour Matching	-0.876(0.042)	-21.053***	-0.314(0.216)	-1.454
Kernel Matching	-0.876(0.045)	-19.444***	-0.299(0.200)	-1.494

*Source: Survey data; ***Significant at 1% level, **Significant at 5% level, *Significant at 10% level*

Table 4.33 shows the impact of CA participation on income variables by providing the average treatment effects on the treated (ATT). CA adopters, on average, show positive effects compared to controls. Income, sales of produce and profit all are reported to increase for the adopters of CA. Costs were also reported to reduce for treated farmers. ATTs for the different matching techniques are similar and, with the same numbers of controls.

Further income related variables include access to credit and the capacity to create savings by utilising additional or disposal income. Credit access and savings capacity are shown to increase given CA adoption with savings capacity having the highest impact on the treated. This corresponds with the increased yield, sales, and profits reported in section 4.5.2 and with studies that indicate savings increase upon adoption due to increased cost and labour savings (Baudron et al., 2014).. The t-statistics for all the ATTs quoted in Table 4.34 (except access to assets in Zimbabwe) are all above the 99% confidence level for a two tailed test (T> t = 2.576), indicating highly significant results.

Table 4.33: Impact of CA on food security

	KENYA		ZIMBABWE	
	ATT.(Std eror)	T-stat	ATT.(Std error)	T-stat
Food security				
Nearest Neighbour Matching	0.959(0.018)	52.764***	0.843(0.241)	3.494***
Kernel Matching	0.959(0.015)	62.894***	0.729(0.098)	7.453***
Health and nutrition				
Nearest Neighbour Matching	0.942(0.048)	19.450***	0.286(0.158)	1.806*
Kernel Matching	0.969(0.014)	67.281***	0.124(0.137)	0.903
Change in number of meals per day after CA				
Nearest Neighbour Matching	1.144(0.144)	7.959***	0.614(0.197)	3.125***
Kernel Matching	1.155(0.081)	14.324***	0.574(0.124)	4.647***
Number of months food insecure after CA				
Nearest Neighbour Matching	-5.798(0.393)	-15.130***		
Kernel Matching	-5.791(0.365)	-15.864***	-1.16(0.743)	-1.368

*Source: Survey data; ***Significant at 1% level, **Significant at 5% level, *Significant at 10% level*

Gender disparity is most effectively reduced if the farm workload is reduced and the gender gap for labour is diminished. Farm work is often physically demanding and time-consuming, requiring significant labour input. When the workload decreases, farmers, especially women, have more time available for other activities such as further education, participating in community decision-making, or engaging in other productive endeavours. This can contribute to reducing gender disparities by expanding women's opportunities and empowering them economically and socially. Additionally, with reduced farm workload, women may have more time and energy to access and utilize resources such as extension services, training programs, credit facilities, and market information. Therefore, CA adoption can be viewed as more favourable, especially for female landowners should it be found to decrease farm workload. A dummy variable where 1 = decreased farm workload and 0 = no change or increased farm workload was tested. The results in Table 4.34 show that, on average, farm workload is cited to have decreased more for ACT farmers. Similarly, ACT farmers were more likely to report decreases in labour for female farmers specifically. Additionally, the average treatment effect reported for decreased farm women for women in specific is lower.

The ATT on decreased farm workload using nearest neighbour matching was insignificant for Kenya at all significance levels using a 95% confidence level for a two tailed test (T> t = 1.960).

Results for Zimbabwe are significant and positive at all levels. These findings suggest that Zimbabwean farmers are more likely on average to report decreased farm workload, compared to Kenyan farmers. These findings are contrary to the expected findings of reflexive controls and are in contrast to the previous overall gender disparity variable.

Table 4.34: Impact of CA adoption on access to assets in Kenya and Zimbabwe

	KENYA		ZIMBABWE	
	ATT.(Std error)	**T-stat**	**ATT.(Std error)**	**T-stat**
Access to assets				
Nearest Neighbour Matching	0.645(0.063)	10.237***	0.200(0.212)	0.944
Kernel Matching	0.672(0.037)	18.317***	0.123(0.140)	0.880
Access to credit				
Nearest Neighbour Matching	0.331(0.067)	4.949***	0.029(0.014)	2.022**
Kernel Matching	0.331(0.070)	4.701***	0.029(0.015)	1.938**
Savings capacity				
Nearest Neighbour Matching	0.959(0.018)	52.764***	0.421(0.161)	2.617***
Kernel Matching	0.959(0.020)	47.017***	0.417(0.074)	5.616***

*Source: Survey data; ***Significant at 1% level, **Significant at 5% level, *Significant at 10% level*

4.5.4. The impact of CA on social dynamics and gender disparity

Social dynamics are proxied by solidarity and social cohesion in this study. Social dynamics impacts from CA adoption can contribute to better farmer collaboration and information sharing. Ndah et al. (2015) reports that better social systems also enable effective institutions amongst farmers, normalises innovations, and increases likelihood of adoption. In Table 4.35 adoption of CA shows a reported increase in the social dynamics, solidarity and social cohesion of farmers at statistically significant levels. A possible explanation is that farmers taking part in the ACT project observed improved social relations amongst themselves as they shared information and farming knowledge of how to practice the newly adopted CA methods. This corresponds with the findings in Table 4.15 in section 4.4 as well as the reported findings of improved teamwork in Table A.11 in the appendix.

Table 4.35: Impact of CA adoption on social dynamics

	KENYA		ZIMBABWE	
	ATT.(Std error)	T-stat	ATT.(Std error)	T-stat
Overall social dynamics				
Nearest Neighbour Matching	0.926(0.050)	18.606***	0.314(0.190)	1.654*
Kernel Matching	0.953(0.022)	44.094***	0.219(0.169)	1.294
Solidarity, social cohesion and group work				
Nearest Neighbour Matching	0.959(0.018)	52.764***	0.964(0.335)	2.879***
Kernel Matching	0.959(0.020)	47.208***	0.652(0.274)	2.381**

*Source: Survey data; ***Significant at 1% level, **Significant at 5% level, *Significant at 10% level*

Gender disparity is most effectively reduced if the farm workload is reduced and the gender gap for labour is diminished. Farm work is often physically demanding and time-consuming, requiring significant labour input. When the workload decreases, farmers, especially women, have more time available for other activities such as further education, participating in community decision-making, or engaging in other productive endeavours. This can contribute to reducing gender disparities by expanding women's opportunities and empowering them economically and socially. Additionally, with reduced farm workload, women may have more time and energy to access and utilize resources such as extension services, training programs, credit facilities, and market information. Therefore, CA adoption can be viewed as more favourable, especially for female landowners should it be found to decrease farm workload. A dummy variable where 1 = decreased farm workload and 0 = no change or increased farm workload was tested. The results in Table 4.36 show that, on average, farm workload is cited to have decreased for ACT farmers. Similarly, ACT farmers were more likely to report decreases in labour for female farmers specifically, although the average treatment effect reported for decreased farm workload for women in specific is lower.

The ATT on decreased farm workload using nearest neighbour and kernel matching was insignificant for Kenya at all levels Results for Zimbabwe were significant and positive at all levels. These findings suggest that Zimbabwean farmers are more likely, on average, to report decreased farm workload, compared to Kenyan farmers. These findings are contrary to the overall gender disparity variable, which is statistically significant at all levels for both Kenyan and Zimbabwean farmers. Possible explanations could for this include that Kenyan farmers perceived reduced gender disparity in other ways e.g. access to credit and increased income.

Table 4.36: Impact of CA adoption on gender disparity

	KENYA		ZIMBABWE	
	ATT.(Std error)	**T-stat**	**ATT.(Std error)**	**T-stat**
Overall (decreased) gender disparity				
Nearest Neighbour Matching	0.983(0.012)	84.499***	0.607(0.246)	2.464**
Kernel Matching	0.983(0.012)	81.676***	0.645(0.205)	3.143***
Overall decreased farm workload				
Nearest Neighbour Matching	0.725(0.470)	1.541	0.557(0.144)	3.864***
Kernel Matching	0.723(0.335)	2.159	0.520(0.073)	7.077***
Decreased farm workload for women in specific (2 matches for Zimbabwe)				
Nearest Neighbour Matching	0.215(0.092)	2.324***	0.390(0.041)	9.408***
Kernel Matching	0.216(0.082)	2.638***	0.390(0.047)	8.313***

*Source: Survey data; ***Significant at 1% level, **Significant at 5% level, *Significant at 10% level*
Note: The variables for overall decreased farm workload and decreased farm workload for women in specific study the average effects between the treated and control groups where farmers reported (1 = Yes = overall decreased farm workload and 1= Yes = decreased farm workload for women in specific)

To further investigate gender disparity, chi-square tests were conducted by various categories and the results presented in Table 4.36. It was found that a significant difference was present by country, by farmer gender, and by treatment, while the null hypothesis for differences in means for the country*gender interaction term could be rejected at the 95% level of significance. This implies that the impacts of lessened gender disparity i.e. specific benefits for women were observed in varying degrees by country, by gender and by treatment. Kenyan farmers, ceteris paribus, were more likely to report reduced gender disparity. Similarly, male farmers were more likely to report reduced gender disparity than female farmers. Finally, CA adopting farmers reported decreased gender disparity while non-adopting farmers, on average, reported increased gender disparity. These results correspond with earlier findings were male farmers were likely to self-select into the program than female farmers. The statistically significant, likelihood of Kenyan farmers reporting reduced gender disparity is interesting and could be connected to the findings in Table 4.36 where reduced gender disparity was not observed particularly in farm workload but in potentially other forms.

Table 4.37: Chi-square tests per category for the effects of CA on gender disparity in Kenya and Zimbabwe

	Mean	Std. Dev.	Chi-sq	P-value
Chi-square test by country *H_0: The difference between the means of gender disparity for Kenyan and Zimbabwean farmers is equal to 0*				
Kenya	0.583	0.494	45.22	0.000**
Zimbabwe	0.243	0.763		
Chi-square by household head (farmer) gender *H_0: The difference in the means of gender disparity for male and female farmers is equal to 0*				
Male	0.469	0.618	7.323	0.026**
Female	0.331	0.721		
Chi-square test by treatment *H_0: The difference in the means of gender disparity for ACT farmers and Non ACT farmers is equal to 0*				
ACT farmer	0.637	0.698	260.8	0.000***
Non-ACT farmer	-0.014	0.269		
Chi-square by country*gender interaction term *H_0: The difference between the means of gender disparity for male, Zimbabwean farmers and other farmers is equal to 0*				
Zimbabwean, male farmer	0.327	0.724	-4.2861	0.117
Other farmers	0.445	0.639		

*Source: Survey data; ***Significant at 1% level, **Significant at 5% level, *Significant at 10% level*

4.5.5. The impact of CA on sustainability and the environment

Empirical data report increases in ecosystem services such as nutrient recycling, water retention and improved soil biota post CA adoption (Palm et al., 2014, Thierfelder et al., 2013). The high likelihood of improved soil fertility is also supported by reported practices of CA technologies such as slash and mulch, leaving of stover in the field, and prevention of field burning (please refer to Table A.4 in the appendix for these results). This study's findings on impacts of CA on sustainability and the environment are shown in Table 4.37. CA adoption by Kenyan and Zimabwean farmers is reported to increase soil fertility, adaptation and drought resilience. In Zimbabwe, farmers report decreased forest area cleared in hectares as opposed to Kenyan farmers, adopting CA, who report increased forest area cleared. Possible explanations for this increase include the additional need for/competitive uses of mulch when adopting CA methods. This is also cited as a challenge for CA adopting, Kenyan farmers in section 4.3.3, where farmers cite the widespread use of crop residues for livestock feed and fuel. This additional need for mulching when adopting CA may have led to increased forest area cleared as farmers look for alternative sources of livestock feed or fuel.

Table 4.38: Impact of CA adoption on sustainability and the environment

	KENYA		ZIMBABWE	
	ATT. (Std error)	T-stat	ATT.(Std error)	T-stat
Overall environmental change				
Nearest Neighbour Matching	0.909(0.051)	17.832***	0.257(0.195)	1.320
Kernel Matching	0.936(0.019)	48.430***	0.072(0.175)	0.411
Forest area cleared per hectare				
Nearest Neighbour Matching	0.727(0.042)	17.187***	-0.521(0.174)	-3.005***
Kernel Matching	0.727(0.045)	16.008***	-0.466(0.105)	-4.455***
Soil fertility				
Nearest Neighbour Matching	0.934(0.049)	19.018***	0.736(0.075)	9.873***
Kernel Matching	0.961(0.017)	54.964***	0.808(0.079)	10.173***
Adaptation				
Nearest Neighbour Matching	0.983(0.012)	84.499***	0.650(0.244)	2.663***
Kernel Matching	0.983(0.013)	76.787***	0.683(0.158)	4.327***
Drought Resilience				
Nearest Neighbour Matching	0.983(0.012)	84.499***	0.893(0.209)	4.269***
Kernel Matching	0.983(0.011)	86.639***	0.968(0.147)	6.566***

*Source: Survey data; ***Significant at 1% level, **Significant at 5% level, *Significant at 10% level*

4.6. How impacts contribute to farmers adopting CA in Kenya and Zimbabwe

To be widely adopted, all new technology needs to have benefits and advantages that attract a broad group of farmers who understand the differences between what they are doing and what they need (Food and Agriculture Organization of the United Nations 2021). In the case of conservation agriculture these benefits can be economic, agroeconomic and environmental. Economic benefits can improve production efficiency, create time savings, and reduce labour required for farm production activities. They also lead to cost reductions using technologies such as minimum tillage and reduced labour costs (Nyamangara, Masvaya et al. 2013). Agronomic benefits are those that promote soil health and improve organic matter, soil conservation and the overall soil structure that promotes crops. Environmental benefits such as increased adaptation and drought resilience can help create sustainable, long term positive gains, especially for farmer who rely on family work and subsistence farming (Lalani, Dorward et al. 2017, M. Salomons, A. Braul et al. 2018). When these benefits group together cohesively, the likelihood of adoption is improved.

The observed impacts of CA on the ACT and Non-ACT farmer groups in Kenya and Zimbabwe, show that CA adoption has the ability to create the system of benefits that positively impact the livelihoods of small holder farmers. Farm production was shown to positively increase for maize, beans and sorghum production. Income was positively impacted through the reduction of costs and increased product sales, due to increased farm yield. Food security was also reported to have increased and the number of months spent food insecure to have decreased.

4.7. Conclusion

The chapter focussed on addressing the research objectives, answering the research questions, and testing the research hypothesis of this study. The key variables used in the analysis include the socio-economic characteristics of farmers to account for selection bias using PSM and the variable outcomes of livelihood categories of farm production, food security and income, social dynamics, gender disparity and sustainability and environmental benefits. The adoption of CA was found to create positive impacts across all outcome variable categories. Farm production for maize, beans and sorghum was shown to increase for farmers who adopted CA by taking part in the ACT farmer program, relative to non-adopters. The effects on income were favourable, with statistically significant impacts showing increased yields, sales and decreased costs. Access to credit was shown to be a challenge in section 4.5 and these challenges are shown to be diminished through CA adoption. The capacity to save is even more positively impacted, with likelihoods of increased savings capacity as high as 0.695 times more than Non-ACT farmers. Food security was improved through increased health and nutrition as corresponded by increased yields and increased meals per day and decreased months spent food insecure. The biggest impacts were found to be in improvements in farm yield, maize production, food security and soil fertility with ATEs of at least 0.9 and higher and significant at all levels.

Some of the lowest impacts of adoption of CA were observed in the average effects on access to credit and overall environmental change for Zimbabwean farers|. Decreased farm workload specific to women was found to be significant at all levels. Impacts on gender disparity were statistically significant when compared by country, treatment and gender of farmer household instead.

CHAPTER 5 – DISCUSSION AND RECOMMENDATIONS

This chapter presents a summary of the research findings for the investigation into the impact of conservation agriculture on the livelihoods of Kenyan and Zimbabwean farmers. These findings were instrumental in demonstrating the role of that sustainable agriculture can play in farmer well-being in Kenya and Zimbabwe. The findings also highlighted the varying contexts of the two countries and the resulting policy requirements therein. This is an important topic given that most empirical studies continuously debate on the effects of CA adoption, especially in African farmer contexts. This study was adding to that discourse and shedding light on the varying effects comparable in the two countries. Based on the findings, conclusions were drawn that were translated into policy recommendations provided below and were aimed at raising adoption of CA in Kenya and Zimbabwe. Lastly, although the study contributed to the academic debate on the role of CA in changing farmer livelihoods, further studies are recommended to add more nuance to the subject.

5.1. Summary of findings

The major objective of the study was to test how the introduction of CA methods by small holder farmers in Kenya and Zimbabwe, impacts their farm yield, farm workload, food security, income, gender disparity, social dynamics, and sustainability and environmental benefits. This was done through a comparison of the average livelihood changes between farmers who adopted CA through participation in the ACT adoption programme and those that did not participate. The comparison of effects was conducted using Propensity Score Matching techniques accounting for self-selection bias that was present due to farmers that were opting into the programme given common characteristics. The study also intended to identify determinants of adoption and the non-adoption of CA through the differences in impact and how those differences can be used to influence farmers switching from conventional farming methods to CA.

Cross sectional data for the 2018 period of the ACT programme in Kenya and Zimbabwe was used to compute farm level changes in farm yield, farm workload, food security, income, social dynamics, gender disparity, and sustainability and environmental benefits. To begin, the intensity of adoption levels in both Kenya and Zimbabwe were calculated, showing the magnitude of adoption of the full CA suite at only 26% and 5% respectively. There was also a

0.6% intensity rate of adoption for the full CA suite amongst Zimbabwean farmers who were non-participants in the ACT program.

The impact analysis revealed that smallholder Kenyan farmers in comparison to Zimbabwean farmers differed significantly in the ability of primary school education and the previous participation of a CA beneficiary project to predict the adoption of CA. Zimbabwean farmers were more likely to participate in CA by about 76% with a primary school education compared to their Kenyan counterparts. Zimbabwean farmers in general were also about 2,4 times more likely to participate in CA, ceteris paribus. Interestingly, a Zimbabwean farmer who had previously participated in a CA project was about 1,3 times less likely to participate in the CA project again, compared to their Kenyan counterparts, ceteris paribus.

A formal t-test of mean equality was used to compare the mean propensity scores between the two groups of farmers by farmer group classification (ACT and Non-ACT and by country classification (Kenyan and Zimbabwean).

The study also revealed that the socio-economic characteristics of the ACT farmers were significantly different from those of their non-ACT counterparts in both countries. For instance, ACT farmers were on average more educated than Non-ACT farmers, especially in Kenya. It was also observed that Kenyan ACT farmers in general tended to have previous access to credit compared to their Zimbabwean ACT farmer counterparts. Additionally, they were more likely to be aware of CA related activities in their village or nearby villages. These observed differences introduced selection bias into CA participation.

Two sources of selection bias were identified in the sample. First the ACT program looked at certain attributes like previous beneficiaries and credit access. Secondly, farmers were voluntary participants in the CA project, creating a likelihood of self-selection given education and previous knowledge. The presence of selection bias necessitated the use of propensity score matching to account for the effects on the two farmer groups. A comparison between the two groups using average treatment effect (ATT) found a significant difference in livelihood outcomes with CA farmers being more likely to experience, e.g., increases in farm production, food security, income, access to credit and the ability to save. These results showed that CA adoption matters in impacting the well-being of farmers and promoting the SDGs, as well as goals of the African Union and the Food & Agriculture Organisation.

5.2. Conclusions

The findings revealed that CA farmers were able to increase their livelihoods and improve their wellbeing by gaining various benefits in production and income generating activities. However, it was at low levels of adoption of the relevant CA technologies i.e. the three methods of CA farming. It is therefore likely that higher intensity of adoption may have led to differentiated and impacts on the outcome variables despite their overall positivity. Based on these conclusions, we do not reject the hypotheses I – IV that the implementation of CA by farmers has an impact on the outcome variables categories ((1) farm production, (2) food security and income, (3) social dynamics and gender disparity and (4) sustainability and environmental benefits). These findings are significant and help in understanding the ability to promote adoption in the regions of Bungoma and Laikipia in Kenya and in Mashonaland East and West in Zimbabwe given the positive benefits in livelihoods of smallholder farmers.

The study also concluded that there are significant demographic and socio-economic differences between adopters and non-adopters, which influence CA participation. However, farmers from both Kenya and Zimbabwe experienced similar challenges in adoption, such as lack of appropriate CA equipment, lack of knowledge on the potential benefits of CA, high costs of CA tools and equipment and the competing uses of crop residues. The limitations to the data used in the study are noted in variables such as months food insecure, where the recall period of farmers may have been too long. A recommendation to use data that takes into account potential errors in respondent recall is suggested.

5.3. Policy recommendations

Following this investigation, the results presented in chapter 4, and having concluded that conservation agriculture has a positive impact on the livelihoods of smallholder farmers in Kenya and Zimbabwe, it is imperative to consider the next steps in encouraging adoption in the two regions. The differences in farmer context and socio-economic status and worth pursuing further and incorporating into the mode of implementation of CA activities amongst these farmer communities. This study makes a number of policy recommendations on this and other issues of importance in conservation agriculture. Based on this research, CA can be adopted as a sustainable model of agriculture for smallholder farmers. CA allows farmers to improve their soil health, the drought resilience of their crops, and promotes adaptation of their produce. Notable differences were found for previous CA beneficiaries in Zimbabwean farmers compared to Kenyan farmers and their opting into the ACT program. Therefore, it is recommended that differentiated targeting of farmer adopters be implemented in the promotion of CA. Farmers with previous access to credit were more likely to adopt CA, showing a disproportionate advantage of access to capital leading to self-selection. Government schemes and agricultural representatives could use this to their advantage and promote CA adoption as an indicator of credit worthiness, therefore increasing knowledge of CA systems while increasing farmer access to credit.

Government can also target the self-selection of previous CA beneficiaries and farmers who are aware of CA activities in their nearby communities. A buddy system can be introduced where previous beneficiaries are encouraged to bring along a ‘new farmer’ in order to regain accessed to the CA adoption program. This would grow the network of the adoption program while spreading awareness of the CA activities. Similarly, agricultural reps could use a token system that allows previous beneficiaries to accumulate token and share them with other farmers that would not have previously been aware of the activities.

Zimbabwean farmers emerged as having a diversified means of income such as casual labour, businesses, and remittances. This is in contrast to Kenyan farmers who were primarily produce and livestock farmers. Government and agricultural representatives can use the diversified skills of Zimbabwean farmers to link their farming activities with other projects that promote sustainability such as water conservation, removal of invasive species, and wildlife conservation. Using a holistic and diversified approach to the CA absorption program and implementation program can address the need for sustainable practices beyond farming while upskilling farmers to equip them with income generating knowledge.

5.4. Areas of further study

Given the numerous challenges faced by smallholder farmers of SSA in the adoption of CA, who in most cases rarely practice all the three CA principles simultaneously, it is proposed that a further study on how each of the CA components (tillage, organic inputs and cropping systems) and their interactions affect livelihood changes specifically for female-led farmer households.

APPENDIX

Table A.1: Land preparation techniques practiced by farmers per country

	KENYA		TOTAL	ZIMBABWE		TOTAL
	Non-ACT	ACT		Non-ACT	ACT	
Basin Zai pit method	5 (14%)	30 (86%)	35	1 (1%)	139 (99%)	140
Hand ripping	2 (3%)	74 (97%)	76	0 (0%)	11 (100%)	11
Ox-drawn plough	0	0	0	30 (40%)	45 (60%)	75
Conventional ploughing	55 (100%)	0 (0%)	55	14 (67%)	7 (33%)	21
Herbicide use	1 (3%)	28 (97%)	29	0 (0%)	0 (0%)	0
Animal drawn ripping	0 (0.00%)	20 (100%)	20	1 (8%)	11 (92%)	12
Other	21 (75%)	7 (25%)	28	12 (90%)	3 (10%)	15

Table A.2: Planting/seeding techniques practiced by farmers per country

	KENYA		TOTAL	ZIMBABWE		TOTAL
	Non-ACT	ACT		Non-ACT	ACT	
Sow in hole	43 (29%)	106 (71%)	149	0	13 (100%)	13
Planting Basin Zai Pits	8 (27%)	22 (73%)	30	2 (1%)	137 (99%)	139
Furrow planting	4 (80%)	1 (20%)	5	45 (47%)	51 (53%)	96
Jab planting	0 (0%)	11 (100%)	11	0	1 (100%)	1
Animal drawn direct planting	0 (0%)	15 (100%)	15	1 (13%)	7 (88%)	8
Other	29 (94%)	1 (6%)	30	7 (48%)	11 (52%)	18

Table A.3: Weed management techniques as cited by farmers per country

	KENYA		TOTAL	ZIMBABWE		TOTAL
	Non-ACT	ACT		Non-ACT	ACT	
Early sowing just after slashing	13 (10%)	111 (90%)	124	49 (82%)	11 (18%)	60
Early weeding	72 (38%)	119 (62%)	191	0 (0%)	131 (100%)	131
Mulching/uprooting	3 (4%)	65 (96%)	68	2 (3%)	65 (97%)	67
Use of herbicides	2 (3%)	62 (97%)	64	1 (7%)	13 (92%)	14
Others specify	38 (95%)	2 (5%)	40	12 (75%)	4 (25%)	16

Table A.4: Organic soil cover techniques used by farmers per country

	KENYA		TOTAL	ZIMBABWE		TOTAL
	Non-ACT	ACT		Non-ACT	ACT	
Leave cover crop in field after harvesting	1 (2%)	44 (98%)	45	9 (18%)	40 (82%)	49
Prevent burning	40 (39%)	63 (61%)	103	7 (6%)	119 (94%)	126
Set firewalls/firebreaks	5 (31%)	11 (69%)	16	0 (0%)	46 (100%)	46
Slash and leave crop residues in the field	8 (11%)	64 (89%)	72	11 (12%)	82 (88%)	93
Slash natural vegetation and mulch	12 (29%)	30 (71%)	42	1 (2%)	56 (98%)	57
Sow cover crop after main crop	0 (0%)	55 (100%)	55	0 (0%)	1 (100%)	1
Other organic soil cover	44 (70%)	19 (30%)	63	31 (91%)	3 (9%)	34

Table A.5: Sources of credit for farmers in Kenya and Zimbabwe

	KENYA (204 farmers)			ZIMBABWE (202 farmers)		
	Non-ACT (83 obs.)	ACT (121 obs.)	Total	Non-ACT (56 obs.)	ACT (146 obs.)	Total
	Sources of credit					
Bank	20	42	62 (60%)	0	5	5
Microfinance institution	2	14	16	0	0	0
Table banking (local savings and lending group)	3	22	25	0	2	2
Other	-	-	0	0	1	1
Total	25	78	103	0	8	8

Table A.6: Reasons cited for increases observed in food security

	KENYA			ZIMBABWE		
Reasons for changes in food security	Non-ACT	ACT	Total	Non-ACT	ACT	Total
Increased yields or production of crops	15	104	119	5	105	110
Improved under soil fertility	0	12	12	0	1	1
Good quality produce with high nutritive value available	0	5	5	0	0	0
Increased access to diversified foods	0	5	5	0	8	8
Lower costs of production leading to residual income for food	0	7	7	0	1	1
Other reasons cited	3	0	3	1	0	1
No change or negative change	0	2	2	12	0	12

Table A.7: Time needs for traditional versus CA technologies as indicated by Kenyan farmers

	Traditional technology takes more time to implement		CA technology takes more time to implement		TOTAL
	Non-ACT	ACT	Non-ACT	ACT	
Digging planting basins	40 (91%)	4 (9%)	1 (1%)	115 (99%)	160 (100%)
		44 (28%)		116 (72%)	
Ripping by hand, draft animal or tractor	34 (71%)	14 (29%)	1 (1%)	105 (99%)	154 (100%)
		48 (31%)		106 (69%)	
Direct planting in lines	40 (43%)	53 (57%)	1 (2%)	65 (98%)	159 (100%)
		93 (58%)		66 (42%)	
Sowing in hole with machete/stick	41 (49%)	43 (51%)	0 (0%)	76 (100%)	160 (100%)
		84 (53%)		76 (47%)	
Jab planting	29 (33%)	59 (67%)	0 (0%)	60 (100%)	148 (100%)
		88 (59%)		60 (41%)	
Early sowing just after slashing	41 (42%)	57 (58%)	0 (0%)	62 (100%)	160 (100%)
		98 (61%)		62 (39%)	
Mulching	37 (95%)	2 (5%)	0 (0%)	117 (100%)	156 (100%)
		39 (25%)		117 (75%)	
Uprooting weeds rather than cutting	41 (50%)	41 (50%)	0 (0%)	78 (100%)	160 (100%)
		82 (51%)		78 (49%)	
Shallow weeding or weed scrapping	28 (32%)	59 (68%)	0 (0%)	60 (100%)	147 (100%)
		87 (59%)		60 (41%)	
Setting firewalls	41 (60%)	27 (40%)	0 (0%)	92 (100%)	160 (100%)
		68 (43%)		92 (57%)	
Planting of cover crops	40 (98%)	1 (2%)	1 (1%)	118 (99%)	160 (100%)
		41 (26%)		119 (74%)	
Application of manure for fertilizer	41 (41.%)	59 (59%)	0 (0%)	60 (100%)	160 (100%)
		100 (63%)		60 (37%)	
Home preservation of crop residues for mulching	41 (41%)	59 (59%)	0 (0%)	60 (100%)	160 (100%)
		100 (63%)		**60 (37%)**	

Source: Survey data

Please note: Right aligned figures add to row wise totals on the far right. Left aligned figures add to a column wise total.

KEY

[blue] Majority of the farmers indicate that the traditional technology takes more time than the CA technology

[yellow] Majority of the farmers indicate that the CA technology takes more time than the traditional technologies

Table A.8: CA technology labour implications for gender as reported by Kenyan farmers

	CA technology involves females more than males		CA technology involves males more than females		CA technology involves both genders equally		TOTAL
	Non-ACT	ACT	Non-ACT	ACT	Non-ACT	ACT	
Digging planting basins	0 (0%)	51 (100%)	34 (40%)	52 (60%)	7 (30%)	16 (70%)	
		51 (32%)		86 (54%)		23 (14%)	160 (100%)
Ripping by hand, draft animal or tractor	0 (0%)	0 (0%)	25 (21%)	93 (79%)	8 (24%)	25 (76%)	
		0 (0%)		118 (78%)		33 (22%)	151 (100%)
Direct planting in lines	0 (0%)	10 (100%)	24 (59%)	17 (41%)	17 (16%)	92 (84%)	
		10 (6%)		41 (26%)		109 (68%)	160 (100%)
Sowing in hole with machete/stick	38 (36%)	69 (64%)	0 (0%)	9 (100%)	3 (7%)	41 (93%)	
		107 (67%)		9 (6%)		44 (27%)	160 (100%)
Jab planting	0 (0%)	55 (100%)	22 (28%)	56 (72%)	7 (47%)	8 (53%)	
		55 (37%)		78 (53%)		15 (10%)	148 (100%)
Early sowing just after slashing	0 (0%)	11 (100%)	0 (0%)	1 (100%)	41 (28%)	107 (72%)	
		11 (7%)		1 (1%)		148 (92%)	160 (100%)
Mulching	3 (6%)	51 (94%)	0 (0%)	0 (0%)	34 (33%)	68 (67%)	
		54 (35%)		0 (0%)		102 (65%)	156 (100%)
Uprooting weeds rather than cutting	7 (13%)	48 (87%)	0 (0%)	0 (0%)	34 (32%)	71 (68%)	
		55 (34%)		0 (0.00%)		105 (66%)	160 (100%)
Shallow weeding or weed scrapping	3 (12%)	22 (88%)	0 (0%)	4 (100%)	24 (21%)	93 (79%)	
		25 (17%)		4 (3%)		117 (80%)	146 (100%)
Setting firewalls	0 (0%)	2 (100%)	19 (23%)	64 (77%)	22 (29%)	53 (71%)	
		2 (1%)		83 (52%)		75 (47%)	160 (100%)
Planting of cover crops	9 (16%)	49 (84%)	0 (0%)	0 (0%)	32 (31%)	70 (69%)	
		58 (36%)		0 (0%)		102 (64%)	160 (100%)
Application of manure for fertilizer	1 (3%)	39 (97%)	0 (0%)	1 (100%)	40 (34%)	79 (66%)	
		40 (25%)		1 (1%)		119 (74%)	160 (100%)
Home preservation of crop residues for mulching	2 (4%)	54 (96%)	13 (93%)	1 (7%)	26 (29%)	65 (71%)	
		56 (35%)		**14 (9%)**		**91 (57%)**	160 (100%)

Source: survey data

Please note: Right aligned figures add to row wise totals on the far right. Left aligned figures add to a column wise total.

KEY

(green)	Majority of the farmers indicate the CA technology takes more time for **females**
(purple)	Majority of the farmers indicate the CA technology takes more time for **males**
(brown)	Majority of the farmers indicate the CA technology takes more time **for both genders**

Table A.9: Time needs for traditional versus CA technologies as indicated by Zimbabwean farmers

	Traditional technology takes more time to implement		CA technology takes more time to implement		TOTAL
	Non-ACT	ACT	Non-ACT	ACT	
Digging planting basins	3 (%)	15 (%)	19 (%)	118	
		18 (12%)		137 (88%)	155 (100%)
Ripping by hand, draft animal or tractor	3	30	0	28	
		33 (54%)		28 (46%)	61 (100%)
Direct planting in lines	2	23	0	38	
		25 (40%)		38 (60%)	63 (100%)
Sowing in hole with machete/stick	1	25	1	32	
		26 (44%)		33 (56%)	59 (100%)
Jab planting	1	27	1	26	
		28 (51%)		27 (49%)	55 (100%)
Early sowing just after slashing	1	31	1	24	
		2 (56%)		25 (44%)	57 (100%)
Mulching	1	15	21	121	
		16 (10%)		142 (90%)	158 (100%)
Uprooting weeds rather than cutting	19	73	3	61	
		92 (59%)		64 (41%)	156 (100%)
Shallow weeding or weed scrapping	19	86	3	44	
		105 (69%)		47 (31%)	152 (100%)
Setting firewalls	2	26	19	104	
		28 (19%)		123 (81%)	151 (100%)
Planting of cover crops	0	16	2	48	
		16 (24%)		50 (76%)	66 (100%)
Application of manure for fertilizer	3	24	19	113	
		27 (17%)		132 (83%)	159 (100%)
Home preservation of crop residues for mulching	2	19	20	120	
		21 (13%)		**140 (87%)**	161 (100%)

Source: survey data
Please note: Right aligned figures add to row wise totals on the far right. Left aligned figures add to a column wise total.

KEY

(blue) Majority of the farmers indicate that the ***traditional technology*** takes more time than the CA technology

(yellow) Majority of the farmers indicate that the ***CA technology*** takes more time than the traditional technologies

Table A.10: CA technology labour implications for gender as reported by Zimbabwean farmers

	CA technology involves females more than males		CA technology involves males more than females		CA technology involves both genders equally		TOTAL
	Non-ACT	ACT	Non-ACT	ACT	Non-ACT	ACT	
Digging planting basins	10 (26%)	29 (74%)	1 (4%)	25 (96%)	11 (12%)	82 (88%)	158 (100%)
		39 (25%)		26 (16%)		93 (59%)	
Ripping by hand, draft animal or tractor	0	16 (100%)	2 (7%)	28 (93%)	1 (7%)	13 (93%)	60 (100%)
		16 (27%)		30 (50%)		14 (23%)	
Direct planting in lines	0	23 (100%)	1 (6%)	16 (94%)	1 (5%)	20 (95%)	61 (100%)
		23 (38%)		17 (28%)		21 (34%)	
Sowing in hole with machete/stick	1	17 (100%)	0	16 (100%)	1 (5%)	21 (95%)	56 (100%)
		18 (32%)		16 (29%)		22 (39%)	
Jab planting	0	20 (100%)	0	25 (100%)	2 (15%)	11 (85%)	58 (100%)
		20 (34%)		25 (43%)		13 (22%%)	
Early sowing just after slashing	0	18 (100%)	0	24 (100%)	2 (12%)	15 (88%)	59 (100%)
		18 (31%)		24 (41%)		17 (29%)	
Mulching	9 (27%)	24 (73%)	0	20 (100%)	13 (12%)	91 (88%)	157 (100%)
		33 (21%)		20 (13%)		104 (66%)	
Uprooting weeds rather than cutting	3 (7%)	39 (93%)	0	13 (100%)	19 (19%)	81 (81%)	155 (100%)
		42 (27%)		13 (8%)		100 (65%)	
Shallow weeding or weed scrapping	5 (11%)	41 (89%)	0	15 (100%)	17 (18%)	75 (82%)	153 (100%)
		46 (30%)		15 (10%)		92 (60%)	
Setting firewalls	0	15 (100%)	8	69	13 (24%)	45 (76%)	150 (100%)
		15 (10%)		77 (51%)		58 (39%)	
Planting of cover crops	2 (4%)	43 (96%)	0	14 (100%)	0	10 (100%)	69 (100%)
		45 (65%)		14 (20%)		10 (15%)	
Application of manure for fertilizer	5 (18%)	23 (82%)	8 (19%)	35 (81%)	9 (10%)	79 (90%)	159 (100%)
		28 (18%)		43 (27%)		88 (55%)	
Home preservation of crop residues for mulching	5 (8%)	60 (92%)	6 (22%)	21 (78%)	11 (16%)	57 (84%)	160 (100%)
		60 (41%)		**27 (17%)**		**68 (42%)**	

Source: Survey data
Please note: Right aligned figures add to row wise totals on the far right. Left aligned figures add to a column wise total.

KEY

- (green) Majority of the farmers indicate the CA technology takes more time for **females**
- (purple) Majority of the farmers indicate the CA technology takes more time for **males**
- (tan) Majority of the farmers indicate the CA technology takes more time **for both genders**

A.2 Study questionnaire

ACT

African Conservation Tillage Network

"Turning Conservation Agriculture Knowledge into Action"

Conservation Agriculture Impact Evaluation Study: Questionnaire for Household In-depth Interviews in CA 'Hot spots' in Eastern and Southern Africa.

Name of Respondent: ……………………………………………………………………………

Name of the enumerator: ……………………………………………………………………………

Date of Interview: ……………………………… Start time………………… End time………………

Country ……………………………………… County/Region………………………………………

District / Sub-County ……………………..…… Ward/Location: ………………………………………

• Village: ………………………………GPS coordinates: Longitude: ……….……… Latitude: ……………………

• SECTION A: BASIC INFORMATION

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

A2. Gender of the Household Head (Decision maker) 1=Male □ 2=Female □

A3. Level of education of the household head

1=No formal education 2 = Primary 3=Secondary 4 =University 5=Other (specify)___________

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

A5. People living in homestead

Children (0-17)		*Adults (18-59)*		*Elderly (>60)*	
*M*_______	*F*_______	*M*_______	*F*_______	*M*_______	*F*_______

A6. Have you been a beneficiary of any CA project? □Yes □ No

A7. Identification: When did you join the project?   (Indicate the year) ___________________

A8. When did the project end? (Indicate the year) ___________________

A9. Marital status: Married ☐   Never married ☐   Widowed ☐   Separated/Divorced ☐

A10. What is the total size of your land? (In hectares) ……………………………………

A11. Number of animals in the household

a. Cows........ b. Goats....... c. Sheep......... d. Pigs ……e. Chicken …… f. Ducks....... g. Others (specify)

A12. Do you belong to a farmers group?   1=Yes ☐   0=No ☐

A13. What are the major sources of household income? Choose three most important.

a. Crop production; b. Livestock production ; c. Business; d. Casual labour; e. Remittances; f. Employment; g. Others (specify)……………..

• SECTION B: EMPOWERMENT

B1. Have you attended any type of training organized by CA promoters?   ☐1=Yes,   ☐ 2=No

B2. If yes, please provide the following information.

Type of training	Received?		• ype of skills gained (Recall)	Ever used the skills gained ?		Are you still practising the gained skills?	
	Yes	No		Yes	No	Yes	No
1. Land preparation							
2. Seeding							
3. Weed control							
4. Cover Crops							
5. Harvest							
6. Environment conservation							
7. Farmers Group dynamics							
8. Produce marketing							
9. Agribusiness/Entreprеneurship							
10. Other:							

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

(a) ………………………………………………………………………………………….

(b)……………………………………………………………………………………………

(c) ………

- **SECTION C: ADOPTION OF TECHNOLOGIES**

C1. What is the total size of your land in hectares?

1) Area under cultivation (hectares) ______________
2) Area under CA (hectares) ____________________

C2. How have you been managing crop residues/weeds/cover crops in your farm prior to planting? ☐ Slashing with machete or slasher ☐ Mulching ☐ Uprooting weeds (not cutting) ☐ Using knife roller ☐ Use of herbicides

☐ Other (specify)…………..

C3. How do you prepare your farm for planting? ☐ Basin/Zai pit method ☐ Hand ripping ☐Animal Drawn ripping

☐ Tractor drawn ripping ☐ Animal Drawn sub-soiling ☐ Tractor drawn sub-soiling

☐ Others, specify……………………………..

C4. During planting, how do you to carry out planting? ☐ Sow in hole with machete / dibble stick ☐ planting basins / Zai pits ☐ Jab planting ☐ Animal Drawn Direct planting ☐ Tractor Drawn Direct planting ☐ Other (specify)…………..

C5. How have you been controlling or managing weeds in your farm? ☐ Early sowing just after slashing ☐ Mulching ☐ Uprooting weeds (not cutting) ☐ Early weeding ☐ Use of herbicides ☐ Other (specify)…………..

C6. How do you create or maintain organic soil cover in your farm? ☐Prevent burning ☐ Set firewalls/fire breaks ☐ Slash natural vegetation-and mulch ☐ Slash & leave crop residues in the field ☐ Sow cover crop after main crop (Name of cover crops (specify) ..…………………… ☐ Slash cover crops at flowering stage ☐ Leave cover crop in field after harvesting the grain

C7. How do you practice crop diversification or associations? ☐ Crop rotation ☐ Inter-cropping ☐ Relay cropping ☐ Agroforestry (Faidherbi albida)

C8. Are you a mixed farmer ☐Yes ☐No,

If yes, how do you integrate crop with livestock? ☐ Used manure for fertilizer ☐ Used crop residues for livestock feed ☐ Protection of fields from animals (specify how)……………………………………………………………

☐Other (specify) ……………………………………………………………………………………………..

C9. Where is the main source of knowledge and information about the above technologies you have adopted or use?

☐1=CA Project; ☐2=Government Extension; ☐3=Neighbours; ☐4=Other Specify ……………………………….

C10. How do you rate your level of mastery or understanding of the above mentioned technologies of practices?

☐ (1=Low (Need more adaptation); 2=Average; 3=High (Well adapted))

C11. Please indicate the extent in terms of land size to which each technology below has been adopted and practiced in your farm?

Type of technology /practice	Year Started	Beginning (land size started with) (Hectares)	Year ended	Presently (land size currently under each) (Hectares)
Land Preparation				
Sub-soiling (Animal or Tractor)				
Ripping (Hand, Animal or Tractor)				
No-Till Seeding				
Animal Drawn Direct planting				
Tractor Drawn Direct planting				
Jab planter				
Soil Cover				
Leave crop residue in field after harvesting				
Mulching (imported from other fields)				
Uprooting weeds (not cutting)				
Shallow weeding (Weed Scrapper)				
Crop Rotation/Associations				
Crop rotation				
Inter cropping				
Area under Cover crops				
Used manure for fertilizer				

• SECTION D: CHALLENGES OF ADOPTION

D1. Score the challenges facing the adoption of CA technologies (Score in a scale of 1 to 5, where 1 is the least challenging and 5 is the most challenging) as listed below.

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

SECTION E: OVERALL IMPACT

E1. How did the CA interventions (in the project you were involved in) impact on the below listed areas? (Use 1=Improved, 2= Static and 3= Decreased)

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

E2. How has the CA impacts been realized in terms of timelines (Use 1=short term, 2=medium term or 3=long term

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

E3.What is your observation on the following aspects as regard to adoption or involvement on CA at your household level?

Would you say that the total ...	... has increased or decreased after getting involved in CA project (1=Increased, 2=Stagnated 3=Decreased)	Value before CA	Current value (after CA)
At Household Level			
Total cultivated area (hectares)			
Area under CA (hectares)			
Soil fertility			
Total Maize production (kg)			
Total Sorghum production (kg)			
Total Beans production (kg)			
Total Cowpeas production (kg)			
Total Pigeon Peas production (kg)			
Total Dolichos Lablab production (kg)			
Product sales (value in USD)			
Total Production Costs (value in USD)			
Profit (sales minus production costs)			
Food security			
Access to credit			
Savings capacity			
At the Community Level			
Forest area cleared per year (hectares)			
Number of farmers practicing CA in the village			

Solidarity, social cohesion and group work			

E4. How reliable is income obtained from CA project enterprise?

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

E5. What are the top 3 benefits that can be attributed to the CA projects?

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

E6. What other impacts, positive and negative, did CA and the CA project(s) produce?

1. ________________________________

2. ________________________________

3. ________________________________

• SECTION F: FOOD AND NUTRITIONAL SECURITY

F1. What is the change in food and nutritional security since you started using CA (1=Improved, 2= Static and 3= Decreased) ☐

F2. What is the cause of this change in the food and nutritional security?

1. ___________________________
2. ___________________________
3. ___________________________

F3. What is the yield status after using CA (1=Improved, 2= Static and 3= Decreased)

F4. Rank the sources of food in your household before CA and with CA in order of importance (Most important =5, Least Important=1)

Source of food	**Before CA**	**Presently with CA**
Own farm		

Purchase		
Given by neighbours/friends/relatives		
Government		

F5. On average, how many meals per day can your household provide to its members?

	Before the CA	With CA
Number of meals / day		
Number of months food insecure		

• SECTION G: POLICY INTERVENTION ON CA

G1. Are you aware of any policy intervention that governs the CA technologies 1=Yes □ 2=No □

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

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

G2. What kind of policy was it?

....

....

....

G3. Do you understand the policy? 1=Yes □ 2=No □

• SECTION H: INSTITUTIONAL FACTORS

H1. What is the major role of the following institutions?

Institutions	**Key roles**
Local government office	
Local institutions (Churches, Mosques,)	
Private sector agro-dealers	
Local NGOs	
Research institutions	
Extension services,	
Farmers' communities	

1=Provision of seeds, 2=Provision of extension services, 3=Provision of tools, 4=others Specify..........

H2. Has the frequency of meeting the agricultural extensionist increased or reduced after the end of CA project you were involved in? (1=increased, 2=decreased) □

H3. How often were/are you meeting the agricultural extensionist from the project?

(1=weekly, 2= bi-monthly, 3= monthly, 4= a few times a year, 5 = never) □

H4. The contact time with the extensionist was/is adequate? □Yes □ No

H5. How often are you participating in your farmers' group meetings? (1=weekly, 2= bi-monthly, 3= monthly 4= a few times a year, 5 = never)

- **SECTION I: AFFORDABILITY AND SUSTAINABILITY**

I1. How durable are the adoption of CA practices

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

I2. What is the effect on the listed parameters on households adopting CA?

Parameters	**1= Decreased; 2 = Static; and 3 = Increased**
Soil health	
Resilient to drought	
Agricultural yield	
Adaptation to impacts of climate change	
Addressed agricultural calendar bottlenecks	

- **SECTION J: LABOUR AND GENDER**

- J1. Based on your experience and observation which of the following CA technologies requires more time to implement compared to conventional/traditional system? Indicate also who the doer/implementer of the activity is.

CA TECHNOLOGY	**Tick the technique that takes more time to implement on one hectare**		**Mostly done by who** (Use 1=Male 0=Female)
	CA	**Traditional**	
Digging planting basins			
Ripping (Hand, Draft animal or Tractor)			
Direct planting in lines			
Sowing in hole with machete / stick			
Jab planting			
Early sowing just after slashing			
Mulching			
Uprooting weeds (not cutting)			
Shallow weeding (scrapping)			
Setting firewalls			

Planting of Cover crops			
Application of manure for fertilizer			
Home preservation of crop residues for mulching			

J2. Has CA reduced labour and agricultural workload? Use 1=Yes or 0=No □

J3. If yes, whose labour is reduced? Use 1= Men; 2= Women; and 3 = Both □

• SECTION K: ACCESS TO RESOURCES

K1. Did you use any inputs obtained outside the household in the current/last cropping season? 1=yes, 2=no

K2. If yes, how did you access the inputs and tools you used?

Input type (specify the items in the case)	Granted by project (name the project & NGO)		Own Purchase (full cost)		Own Purchase (subsided)	
	What input / tool	Price total	What input / tool	Price total	What input / tool	Price total
Main crop seed						
Cover crop seed						
Fertilisers						
Insecticide						
Herbicides						
Hoes						
Machetes and sticks						
Jab planters						
Other (specify)						

K3. Do you have access to an agro-dealer (inputs suppliers) from your area? □ 1=Yes; 0=No

K4. What is the source of money for purchase of inputs? □ 1=Sale of crops, 2=Sale of livestock, 3=CA project 4=remittance, 5=Sale of labour, 6=other (specify) …………..

• SECTION L: SUSTAINABILITY

L1. Have you ever provided CA services to other farmers? □ Yes □ No

L2. If yes, what type of services? List maximum of three services offered………………………………………………

L3. To how many farmers? ……………………………………

L4. Were you paid for it? □ Yes □ No If yes, how much? ....

L5. Would you say that the area under CA in the community have increased or decreased after the end of the project? □

1 = Increased, 2 = Stagnated, 3 = Decreased, 4 = Do not know

L5. Have you learnt anything new after the CA project related to the project? □ 1=Yes, 2=No

If yes, list a maximum of three

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

● SECTION M: DIFFUSION OF CA INTERVENTIONS

M1. Which of the following items in your household can be attributed to CA project? (Both CA and non-CA respondents)

Item	Rank the appropriate ones (1= more important, to the last, cross if no)
1.Increase household income	
2.improve food security	
3.Increase children's education	
4. Purchase assets (specify): …………….…..	
5.Improved house	
6.Start a new business	
7. Other (specify):	

For Non-beneficiaries of the CA project:

M2. Are you aware of CA Project activities in your village or nearby villages? □ 1=Yes, 2=No

M3. If yes, where did you get information about the Project? □

1=Village leaders, 2=Extension workers, 3=Farmers in the village, 4 = radio broadcast 4=others (specify)

M4. Are there other related projects in your area promoting CA? □ 1=Yes, 2=No

M5. Have you learned any new thing that was introduced by CA project? □ 1=Yes, 2=No

M6. If yes, mention how you heard of it

…………………………………………………………………………………………………
…………………………………………………………………………………………………

● SECTION J: ACCESS TO CREDIT

Has the access to credit increased or decreased since the introduction of CA project?	1 = increase, 2 = stagnate, 3 = decrease 4. Do not know
Have you ever accessed credit?	□ yes □ no
If yes, for what?	□ agricultural production □ health/domestic issue □ running of business □ construction investments □Other(specify)…………………………………………….
If no, what is the reason?	□ lack of awareness □ high interest rates □ fear or risk averseness □Other (specify)…………………………………….

What was the value of the credit (Value in USD)	....
What was the source of credit?	....
How far is the nearest financial institution?	……………. kilometres
What forms of savings do you practice? *(tick all appropriate options)*	□ cash saving □ livestock investments □ labour exchange □ cereal storing □Other (specify)………………………………………

NOTES:

- 2.5 acres = 1 hectare; or multiply "y" acres by 0.4 to get hectares.

THANK YOU VERY MUCH FOR YOUR TIME AND COOPERATION

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