

**The impact of conservation agriculture adoption on farmer welfare: a comparative  
assessment of Kenya and Tanzania**

**By**

**Brian Mpande**

**Submitted in partial fulfilment of the requirements for the degree of MSc Agric  
(Agricultural Economics)**

**Department of Agricultural Economics, Extension and Rural Development**

**Faculty of Natural and Agricultural Sciences**

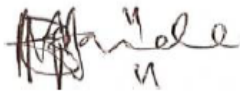
**University of Pretoria**

**South Africa**

**May 2021**

## DECLARATION

I, **Brian Mpande** declare that this dissertation, which I hereby submit for the degree of Master of Science in Agricultural Economics at the University of Pretoria, is my own work and that it has not been previously submitted by me for a degree at this or any other institution of higher learning.



Signature: \_\_\_\_\_

Date: 20<sup>th</sup> May 2021

## **DEDICATION**

This dissertation is humbly dedicated to my Dad, Mr Benson Mpande and to the all-mighty God.

## ACKNOWLEDGMENTS

The completion of this project would not have been a success without the sufficient grace of God almighty. My sincere gratitude goes to my supervisor, Professor Eric D. Mungatana for his tireless counsel, critique and suggestions rendered in producing this report. I must mention that it was a great honour having him as my supervisor. His mentorship contributed to a large extent to my academic and professional development especially in impact assessment analysis.

My deepest appreciation goes to the African Economic Research Consortium's collaborative Masters in Agricultural and Applied Economics (CMAAE) program for the scholarship as well as the research grant which enabled me to do my studies without worrying about funding. My sincere gratitude goes to the African Conservation Tillage Network (ACT) for making available the dataset used in this study. I also extend my deepest appreciation to Ms Christa VanLoggerenberg for the guidance and moral support she rendered in making sure that my stay in Pretoria was worthwhile.

Finally, I would like to thank my parents and all the members of the family for their moral and spiritual support especially when I felt like giving up. Special thanks go to Nchimunya Mapani and Chipo Mpande for being my strong support system during this endeavour.

# **The impact of conservation agriculture adoption on farmer welfare: a comparative assessment of Kenya and Tanzania**

By

Brian Mpande

**Degree:** MSc Agric (Agricultural Economics)

**Department:** Agricultural Economics, Extension and Rural Development

**Supervisor:** Prof. Eric D. Mungatana

## **ABSTRACT**

This paper used propensity score matching (PSM) technique and pooled cross-sectional data from 407 observations with 256 conservation agriculture (CA) adopters and 151 non-adopters from Kenya and Tanzania, to test whether CA causally improves smallholder farmer's welfare. We find mixed results showing that CA has a statistically significant and positive impact on climate change adaptation, drought resilience, total maize production, food security, number of meals per day, household income, accumulation of productive assets, reduction of gender inequalities, improving social cohesion, reduced forest area cleared and soil health improvement. CA has a negative and statistically significant impact on total agricultural yield, agricultural production costs, and number of food insecure months, CA has no impact on addressing agricultural calendar bottlenecks. Since the cross-country analysis showed higher CA adoption rates in Tanzania relative to Kenya, policy could increase adoption rates in the latter by focussing on the less educated farmers, increasing access to input markets, demonstrating benefits from CA projects, and improving farmer mastery of CA technologies. The findings shed light on the role of sustainable agricultural practices and highlight cross-country experiences of CA technologies in improving the welfare of smallholder farmers.

**Keywords:** Conservation agriculture; propensity score matching; welfare; Kenya; Tanzania.

## TABLE OF CONTENT

DECLARATION .....	i
ACKNOWLEDGMENTS .....	iii
ABSTRACT .....	iv
TABLE OF CONTENT .....	v
LIST OF TABLES .....	vi
LIST OF FIGURES .....	vii
ACRONYMS .....	viii
CHAPTER 1: INTRODUCTION AND BACKGROUND .....	1
CHAPTER 2: METHODOLOGY .....	5
1.1. Study area and data sources .....	5
1.2. Analytical framework and estimation techniques .....	6
CHAPTER 3: RESULTS AND DISCUSSION.....	10
3.1 Impacts of CA adoption on small holder farmer welfare.....	10
3.2 Cross-country policy lessons arising from CA adoption category differences.....	19
CHAPTER 4: CONCLUSION .....	24
REFERENCES .....	26
APPENDICES .....	34

## LIST OF TABLES

Table 1. 1: Outcome variables used to measure impact on welfare.....	6
Table 3. 1: Household descriptive characteristics by treatment .....	11
Table 3. 2: Propensity score estimates of CA adoption .....	12
Table 3. 3: Impact of CA adoption on agronomic outcomes .....	15
Table 3. 4: Impact of CA adoption on food security and nutrition outcomes .....	16
Table 3. 5: Impact of CA on economic outcomes .....	17
Table 3. 6: Impact of CA on gender and social outcomes .....	18
Table 3. 7: Impact of CA on environmental outcomes .....	18
Table 3. 8: Household descriptive characteristics by country of residence .....	19
Table 3. 9: Probit regression of CA adoption with education and country interaction term .....	21
Table 3. 10: Key insights from individual probit models with interaction terms .....	22

## LIST OF FIGURES

Figure 3. 1: Kernel density distribution of estimated propensity scores.....	13
Figure 3. 2: Histogram density distribution of estimated propensity scores.....	13



## ACRONYMS

FAO	Food Agricultural Organisation of the United Nations
CA	Conservation Agriculture
ACT	African Conservation Tillage Network
GoK	Government of Kenya
GDP	Gross Domestic Product
NGO	Non-Governmental Organisation
EU	European Union
GTZ	German Trust Fund
URT	United Republic of Tanzania
MTM	Minimum tillage combined with Mulching
PSM	Propensity Score Matching
ATT	Average Treatment effects on the Treated
NN	Nearest Neighbour
KM	Kernel Matching
Ha	Hectares
SSA	Sub-Saharan Africa

## CHAPTER 1: INTRODUCTION AND BACKGROUND

This paper uses a comparative approach to assess the impacts of conservation agriculture (CA) adoption on the welfare of smallholder farmers in Kenya and Tanzania. CA is a concept for resource-efficient agriculture production based on the simultaneous use of three key principles viz.: (1) minimum or no mechanical soil disturbance, (2) permanent organic soil cover and (3) diversified crop rotations (FAO, 2009). These principles integrate water, soil, and biological resource management with external inputs to increase biological processes above and below the ground (e.g. see Giller *et al.*, 2009). It follows that CA is promoted as a technology that improves soil health and other biotic factors, and enables more efficient use of natural resources (e.g. Hobbs, 2007).

In Kenya and Tanzania, agriculture is mainly rainfed and as such, vulnerable to climate variability and drought. Low inherent fertility of tropical soils and degradation, nutrient deficiency and water stress are the key factors that impend agriculture in these countries (Shetto and Owenya, 2007; Marenya *et al.*, 2017). This contributes to low crop yields and production for smallholder farmers, which subsequently affects their welfare negatively. CA is currently promoted as a technology that reduces soil degradation, mitigates drought effects, increases crop yields, reduces production costs, and is a sustainable farming practice (Hobbs, 2007; Corbeels *et al.*, 2014). These claims have raised the interest in studying CA impacts on the welfare of farmers.

Agriculture is critical to Kenya's economy and rural development, contributing 26% of the Gross Domestic Product (GDP) and another 27% of GDP by implication through linkages with different sectors (GoK, 2017). However, about 51% of Kenya's population is food insecure with two thirds of the country being semi-arid to arid. Land degradation, decreasing farm sizes, unreliable rainfall, limited access to credit and high cost of farm supplies are serious problems for farmers (Kipkemboi, Lalit and Richard, 2021). As far back as 2005, the Kenyan government and stakeholders had affirmed the need to transform the agriculture sector, calling for a switch to modern farming technologies such as CA to eradicate hunger and poverty (Kaumbutho and Kienzle, 2007; Kipkemboi, Lalit and Richard, 2021). CA in Kenya is not in itself a new notion as some farmers have long practiced facets of it, although they had not named it as such. It has been promoted through different projects since the 1970s by Government and many Non-Governmental

Organisations (NGOs) (Van Hulst and Posthumus, 2016; GoK, 2017). This includes the National Soil and Water Conservation Project developed with assistance from SIDA, the EU-funded Agroecology based aggradation CA, CA for Sustainable Agriculture and Rural Development funded by the German Trust Fund through the African Conservation Tillage Network, and FAO (Gathiru and Ong, 2006; Kaumbutho and Kienzle, 2007; Tittonell *et al.*, 2012; Kipkemboi, Lalit and Richard, 2021). Despite these efforts, CA adoption has been low in Kenya (Kinyumu, 2012). Kassam *et al.*, (2009) reports a 0.6% CA adoption rate of the 2008 to 2009 cropped land, which improved to 4% for the adoption of minimum tillage combined with mulching by 2016, as observed by Marenya *et al.*, (2017). Mkwambisi *et al.*, (2019) observed an adoption rate of 10% for CA related techniques by 2018. The low adoption rates can be attributed to a myriad of reason among them limited access to extension services, labour constraints if herbicides are not used for weeding, inadequate tools and equipment, and failure by farmers to simultaneously use all the three basic CA principles (Kassam *et al.*, 2009; Kinyumu, 2012; Van Hulst and Posthumus, 2016).

Despite there being a relatively substantial and increasing body of literature on CA impact in Sub Saharan Africa (SSA) ( e.g. Corbeels *et al.*, 2014; Manda *et al.*, 2016; Mango *et al.*, 2020; Pannell *et al.*, 2014; Pender & Gebremedhin, 2008; Siziba *et al.*, 2019; Stevenson *et al.*, 2014; Tambo & Mockshell, 2018), literature on Kenya is arguably scanty and the direction of impact mixed. Kinyumu, (2012) reported a positive impact of CA on maize (*Zea mays L.*) and beans (*Phaseolus vulgaris L.*) yields from experimental data in Kenya. In a study carried out in Laikipia district after the 2001 long rains, the GHARP/KRA project showed increased yield for major crops grown under CA compared to those under conventional farming (Kaumbutho and Kienzle, 2007). However, Rosenstock *et al.*, (2014) reported a negative impact on yield in Kaptumo, attributed to a wide range of socioeconomic and biophysical factors that render CA inappropriate for resource limited smallholders. In contrast to a study in nine Sub-Saharan African countries where Tambo & Mockshell (2018) could not determine the impact CA on small holder farmers income in Kenya due to the relatively low numbers of adopters, Micheni *et al.*, (2016) reported positive impacts.

Despite agriculture contributing to about 50% of GDP in Tanzania, production and yields remain low, with effects on food security and welfare especially of smallholder farmers. This situation has been attributed to declining soil fertility, erratic and unreliable rainfall, soil erosion, and traditional farming practices such as intensive tillage and removing crop residues (URT, 2001, 2003). This is

made worse by the fact that 60% of Tanzania is semi-arid, and close to 33% of the land receives less than 750mm of rainfall (Lugandu *et al.*, 2011). It is the premises of this paper that promoting the principles of CA in Tanzania will likely mitigate these challenges.

CA in Tanzania can be traced back to the 1950s when government extension programs enhanced physical soil and water conservation structures to control surface water runoff (Shetto and Owenya, 2007). CA interventions include the Hifadhi Ardhi Dodoma project, which started in 1973 and covered the eroded areas of Dodoma, and the Soil Conservation and Agroforestry Project Arusha, which started in 1989 with support from the Swedish Embassy and focused on land management (Gathiru and Ong, 2006; Kangalawe, Christiansson and Östberg, 2008). Others include CA for Sustainable Agriculture and Rural Development, funded by the German Trust Fund through the African Conservation Tillage Network and FAO, and facilitated farmer training and implements supply (Gathiru and Ong, 2006; Shetto and Owenya, 2007; Tittonell *et al.*, 2012; Kipkemboi, Lalit and Richard, 2021). The Selian Agricultural Institute, Nandra Engineering Ltd (a private firm that produces CA implements), and Research Community and Organizational Development Associates have been involved in the promulgation of CA.

Despite these efforts, CA adoption rates in Tanzania remain low (Ndah *et al.*, 2015). Marenya *et al.*, (2017) reports an 11% adoption rate for minimum tillage combined with mulching. An improved CA adoption rate of 17% was reported by Tambo & Mockshell, (2018). Survey results reported 8.0% and 29.1% adoption rates for cover cropping and minimum tillage respectively in Dodoma. (Kahimba *et al.*, 2014) reports an adoption rate of 16.6% and 23.7% for cover cropping and minimum tillage in the Arusha region. The low adoption rates have been attributed to free livestock grazing where crop residues are used as fodder, labour intensiveness, and insufficient capital to invest in modern technologies. Other challenges include lack of training, land ownership, and failure to simultaneous apply the three basic CA principles (Mkomwa, Mussei and Mwakimbwala, 2007; Ndah *et al.*, 2015).

Literature on CA impacts on smallholder farmers in Tanzania remains scanty and there exist inconsistencies in the direction of impact. Amare *et al.* (2012) report a positive and significant impact of one CA component (crop rotation) on farmers' income and consumption expenditure in a causal estimation using propensity score matching and switching regression. Tambo &

Mockshell (2018) report a positive impact of adopting all three CA techniques on income among households in Tanzania. In an on-farm conservation tillage trial conducted from 2005 to 2008 in North Eastern Tanzania, Enfors *et al.* (2011) reported positive impact of CA on maize yield. However, Rosenstock *et al.* (2014) reported a negative impact of CA adoption on yield in Koleru, which was attributed to factors like insecure land tenure, lack of access to information, and livestock pressure.

It follows from the above that CA adoption rates in Kenya and Tanzania are generally low, with relatively higher adoption rates for some CA technologies in Tanzania (Ndah *et al.*, 2015). Investigating the cross-country differences in CA adoption rates, experiences and impacts through a comparative study would be of interest to policy. Such a cross-country comparison will allow policy makers and CA promoters to analyse CA impacts in different settings, as several published studies base their findings on location specific, cross-sectional surveys (Hobbs, 2007). Evidence from cross-national comparisons could heighten awareness on promising CA practices and facilitate sharing of experiences on CA developments with positive impact to farmers' welfare (Fleming, 1970). Further, it would enable either country to figure out what works and what does not work, which could lead to improved international (bilateral) understanding of CA impacts. This will also close the knowledge gap regarding the need for analysing the impacts of CA beyond individual countries.

Consequently, this study uses a comparative approach to assess CA impacts on the welfare of smallholder farmers in Kenya and Tanzania. First, it determines the impact of CA on various welfare outcomes using a quasi-experiment. It then draws cross-country policy lessons by comparing and contrasting CA experiences in Kenya and Tanzania. The study's main contribution will be to show how CA affects different outcome variables at a cross-country level to the benefit of policies that promote sustainable agricultural development. The rest of this paper is presented as follows: we outline the methodology in Section 2, discuss the results in Section 3, and conclude and make policy recommendations in Section 4.

## CHAPTER 2: METHODOLOGY

### 1.1. Study area and data sources

Data for this paper comes from a survey conducted by the African Conservation Tillage Network (ACT) in May and June 2016 under the “conservation agriculture impact evaluation” project, which sought to assess the impact of CA on the welfare of smallholder farmers in four Sub-Saharan African countries viz. Kenya and Tanzania (East Africa), and Zambia and Zimbabwe (Southern Africa). This paper pools data from Kenya and Tanzania, while a sister paper pools data from Zambia and Zimbabwe (Ngalande, 2021). Data from Kenya and Tanzania was collected from 407 households, 256 of which were CA adopters and 151 were controls. Three districts were selected from Kenya viz. Bungoma (82 households), Laikipia (101 households), and Webuye (21 households), and two from Tanzania viz. Mbeya (102 households) and Babati (101 households). The study used multistage sampling to choose wards and villages and made efforts to ensure representativeness of the sample depending on sampling unit populations. Proportionate random sampling was used to select wards from districts, villages from wards, and households from villages. The control and treatment groups were drawn from similar agroecological conditions from within villages as stated already. Data was collected using semi-structured questionnaires by trained enumerators through personal interviews. The survey collected information on empowerment, adoption of technologies, overall impact of technologies, access to resources, labour and gender, among others. The survey asked both treated and control farmers to state, based on their experiences, whether participation in CA projects increased, reduced or had no impact on the outcome variables listed in Table 1. 1. As such the outcome variables was defined as a categorical. Thus, caution is given in interpreting the results in the results and discussion chapter as they as the outcome variables used are not continuous.

**Table 1. 1: Outcome variables used to measure impact on were**

Outcome variable	Definition
Total agricultural yield	Dummy=1 if total agricultural yield increased, 0 otherwise
Total maize production	Dummy=1 if total maize production increased, 0 otherwise
Resilience to drought	Dummy=1 if resilience to drought increased, 0 otherwise
Adaptation to climate change	Dummy=1 if adaptation to climate change is enhanced, 0 otherwise
Number of meals per day	Continuous
Number of food-insecure months	Continuous
Food security	Dummy=1 if food security improved, 0 otherwise
Household income	Dummy=1 if household income increased, 0 otherwise
Accumulation of productive assets	Dummy=1 if ability to accumulate productive assets increased, 0 otherwise
Addressing agricultural calendar bottlenecks	Dummy=1 if ability to address agricultural calendar bottlenecks increased, 0 otherwise
Total agricultural production costs	Dummy=1 if total agricultural production costs increased, 0 otherwise
Social cohesion	Dummy=1 if social cohesion enhanced, 0 otherwise
Gender disparities	Dummy=1 if gender disparities reduced, 0 otherwise
Soil health	Dummy=1 if soil health improved, 0 otherwise
Forest area cleared per year	Dummy=1 if forest area cleared per year reduced, 0 otherwise

*Source: Author's survey data.*

## 1.2. Analytical framework and estimation techniques

In our study, CA was defined as owning a proportion of land used for one of the CA practises. Adopting CA technology is one of the many actions a farmer takes to increase the overall benefit or profit of farming. In most cases, maximising expected benefits is a function of labour, available land, access to credit, access to information and other constraints, including lack of appropriate CA equipment, that informs the farmer's decisions at a given time (Marenya and Barret , 2007; Kassie *et al.*, 2015). We considered the expected profit or improvement in farmers' welfare as a function of crop choice and the discrete decision to adopt CA in a given period. The modelling of

a farmer trying to estimate the gains from increased agronomic outcomes, improved food security and nutrition outcomes, increased economic and environmental outcomes, and other benefits from the adoption of CA technologies is explained by (Feder, Just and Zilberman, 1985).

Much as adoption of CA is expected to lead to positive outcomes, estimating such outcomes in nonexperimental research is an exigent task because of the difficulty of observing counterfactuals (Rosenbaum and Rubin, 1983; Winters *et al.*, 2010). Non-randomised assignment to the treatment group leads to biased results because the outcomes of the treated and control groups are different even in the absence of treatment (Winters *et al.*, 2010). For instance, adoption of CA is none randomly allocated to the treated (adopters) because they may choose to adopt or not, based on unobservable characteristics. In other cases, technology adoption may be the result of a funded project or government policy that creates incentives for farmers. As a result, we follow the causal inference framework given by Rubin. (1974) to estimate the causal effect of adoption of CA on a set of outcome variables. In other words, we estimate the average treatment effect on the treated (ATT) on farmer welfare outcomes. Many studies have relied on propensity score matching (PSM) techniques to assess the impact of modern agricultural technologies and adoption methods (e.g Kuntashula and Mungatana 2015; Makunike and Kirsten 2018; Mango *et al.* 2020; Ng'ombe *et al.* 2014). In this study, adoption of conservation agriculture is used as the treatment variable while the outcome variables are as described in Table 1. 1.

Rubin. (1974) explains the outcome framework for estimating ATT as follows:

$$E(Y_1 - Y_0 \setminus T = 1) \quad (1)$$

Here,  $E$  represents the expected difference in outcome ( $Y_1 - Y_0$ ) between the treatment and the counterfactual situation, i.e., difference in the assumption that farmers had adopted CA,  $T=1$  and if CA had not been adopted,  $T=0$ . Two assumptions are required to validate matching methods. The first being the conditional independence assumption, which says that given a set of observable independent variables  $X$ , the likely outcome in the case of no CA adoption ( $Y_0$ ) is not dependant on the treatment assignment ( $T$ ), as shown below.



$$Y_0 \parallel T \setminus (X) \quad (2)$$

The overlap condition or common support is the second assumption which requires that characteristics in the treatment and control groups should be as similar as possible. It involves matching units from the treatment and control groups with a similar propensity score. In this case, we ignore and drop control units that do not share a propensity score with the treatment within the common support (Khandker and Samad, 2009). The two assumptions above ensure that within each cell defined by  $X$ , the allocation to treatment is random. The outcome of the control observations can be used to approximate the counterfactual effect of those receiving treatment in the absence of treatment.

It is better to use many observable characteristics to match truly similar units. However, suppose the list of matching variables is too long, too detailed, or contains exceptional values. In this case, it may be difficult to find two units with the same characteristics in the treatment and comparison groups. The larger the number of variables for matching, the more difficult it is to find a good match. To overcome the curse of dimensionality, Rosenbaum and Rubin (1983) showed that matching on a single continuous variable, the propensity score (PS), is possible instead of matching a multidimensional covariate vector. Theoretically, Heckman, Ichimura and Todd, (1998) define a propensity score as the conditional probability,  $P$ , of participating in a program based on the observed characteristics,  $X_i$  and is mathematically expressed as follows:

$$P(X_i) = \Pr(T = 1|X_i) \quad (3)$$

where  $X$  is a vector of covariates and  $T$  denotes treatment status, which takes a value of 1 with treatment. These propensity scores are normally not known. In this study, they were estimated using a probit regression in which the dependent variable was equal to one if the household had land under CA and zero otherwise. The balancing property for the propensity scores was checked to ensure that the treated and control observations had similar distribution of propensity scores within the region of common support (Beal and Kupzyk, 2014). In estimating propensity scores, variables that were correlated with the outcome and/or treatment variables were included. A robust

probit model that satisfied the balancing property within the region of common support, was selected as shown in equation (4).

The matching procedure was executed using three matching algorithms to ensure robustness in the estimates. First, we used nearest neighbour (NN) matching, in which the observation from the control group is chosen as the matching participant for a treated observation that is closest to the propensity score. We used NN with replacement, where a single observation could be used more than once as a matching partner. This allows for an increase in the average quality of matches and a decrease in bias (Caliendo and Kopeinig, 2008). Second, we executed a stratification and interval matching procedure. Stratification matching divides the region of common support for the propensity score into intervals or strata and computes the effect of each interval by taking the mean difference in outcomes between treated and control groups. Using intervals (strata) under normality removes most of the bias in the covariates (Caliendo and Kopeinig, 2008).

Third, while NN and stratification matching techniques use at most a small number of observations from the contrast group to construct the hypothetical outcome of a treatment observation, kernel matching (KM) is a nonparametric matching estimator. KM uses weighted means of all units in the comparison group to construct the hypothetical outcome (Caliendo and Kopeinig, 2008). Consequently, KM has lower variation because it uses more information. However, KM has the possibility of using poor matches. Therefore, Caliendo and Kopeinig, (2008). emphasise the importance of properly imposing the common support condition.

## CHAPTER 3: RESULTS AND DISCUSSION

### 3.1 Impacts of CA adoption on small holder farmer welfare

We followed the impacts assessment literature (e.g. Rosenbaum and Rubin, 1983) to initially establish whether there existed systematic pre-treatment differences between the treated (CA-adopters) and controls (non-adopters). Abadie and Imbens (2016) and Caliendo and Kopeinig (2008) observe that this step is important in establishing whether there is a case for selection bias in the sample. Table 3.1 shows the *t*-test and chi-square comparisons of means by CA adoption category.

Table 3. 1 shows that total land size, land size under cultivation, all variables under (i) membership, training and skills acquisition, (ii) access to information, and (iii) institutional services show statistically significant differences between the treated and controls, thus suggesting the presence of self-selection bias. Table 3. 1 further shows CA adopters are more likely to own larger pieces of land in total, have larger land sizes under cultivation, be members of farmer groups, have received training in CA, have benefited from CA projects, have mastery of CA technologies, have information on CA, and have access to credit and agro-dealers relative to non-adopters.

Following the selection bias suspicion, we used STATA 15 to statistically match the treated and controls prior to implementing the impact analysis. We estimated propensity score equation (4) with callipers set at 0.001 and confirmed that the balancing property was satisfied prior to matching. Using this approach, STATA statistically ensures that the assignment to treatment is ‘random’, which means that treatment and controls are observationally similar on average.

$$\begin{aligned}
 P(\text{CAadopt}) = & \beta_0 + \beta_1 \text{country} + \beta_2 \text{age} + \beta_3 \text{gender} + \beta_4 \text{HHsize} + \beta_5 \text{total}_{\text{landsize}} + \\
 & \beta_6 \text{landcultivatedsize} + \beta_7 \text{membership} + \beta_8 \text{evirskill} + \beta_9 \text{benftCA} + \beta_{10} \text{accessexten} + \\
 & \beta_{11} \text{accessCAinfo} + \beta_{12} \text{credit} + \beta_{13} \text{agrodealer} + \text{error term}
 \end{aligned} \tag{4}$$

Finally, a comprehensive literature review and comparison of different model specification informed the choice of covariates used in equation (4).

Table 3. 2 shows the output from estimating propensity score equation (4). The predicted propensity scores for CA adopters ranged from 0.059885 to 1.000 (mean 0.86342) and 0.05320 to 0.99994 (mean 0.72250) for non-adopters, which implied that the assumption of common support was satisfied in the region 0.05320 - 0.99994 (Figure 3. 1). A visual inspection of Figure 3. 1 and Figure 3. 2 shows significant overlaps between the treated and controls as further confirmed by a significant chi-squared test and p-value of 0.000.

**Table 3. 1: Household descriptive characteristics by treatment**

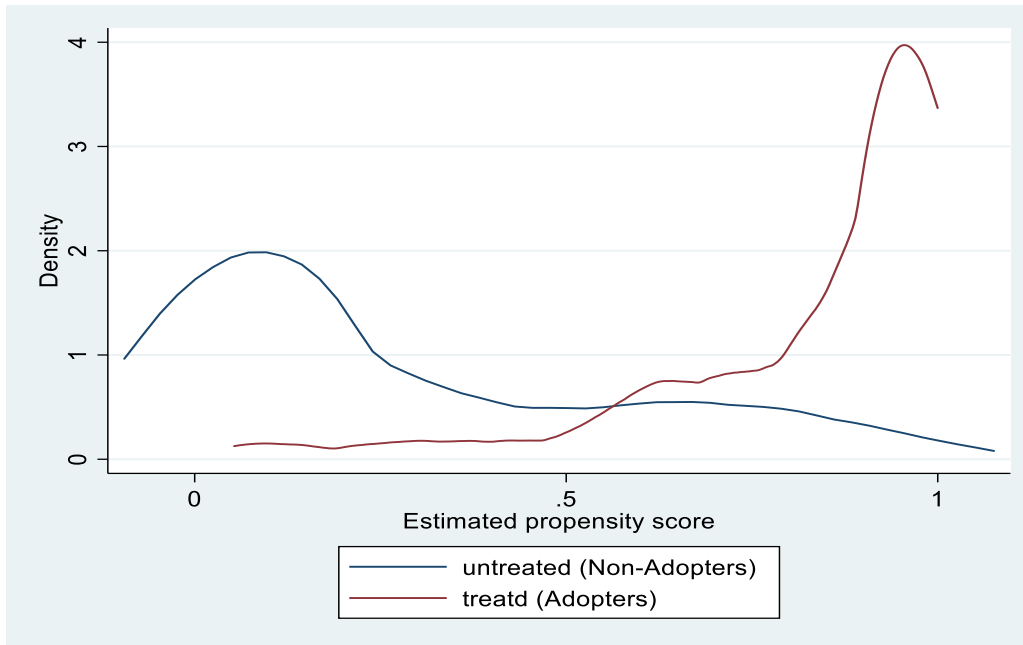
Variable	CA adopters (N = 256)	Non-adopters (N = 151)	Chi2,  t -value
<b>Household and plot characteristics</b>			
Age of household (HH) head (years)	52.309 (0.76)	52.119 (0.81)	0.164
Gender of HH head (1=female, 0=otherwise)	0.25 (0.20)	0.238 (0.22)	0.069
Education level of HH head (years)	8.253 (0.11)	7.721 (0.32)	1.518
Household size (number of persons)	6.859 (0.06)	7.026 (0.41)	0.492
Total land size (ha)	2.085 (0.12)	1.647 (0.14)	2.455
Land size under cultivation (ha)	1.574 (0.51)	1.145 (0.61)	3.351
<b>Membership, training and skills acquisition</b>			
Member of farmer group (1=yes, 0=otherwise)	0.906 (0.41)	0.583 (0.31)	59.13
Had environmental conservation training (1=yes, 0=otherwise)	0.746 (0.12)	0.311 (0.18)	73.96
Benefitted from any CA project (1=yes, 0=otherwise)	0.945 (0.21)	0.358 (0.36)	165.4
At least moderate mastery of CA technologies (1=yes, 0=otherwise)	0.66 (0.24)	0.06 (0.37)	139.2
<b>Access to information</b>			
Had contact with extension services (1=yes, 0=otherwise)	0.699 (0.01)	0.768 (0.08)	31.33
Had information about CA (1=yes, 0=otherwise)	0.734 (0.19)	0.543 (0.30)	15.57
<b>Institutional services</b>			
Ever accessed credit (1=yes, 0=otherwise)	0.387 (0.18)	0.205 (0.20)	14.38
Had access to agro-dealer (1=yes, 0=otherwise)	0.895 (0.10)	0.563 (0.17)	59.25

Source: Computations from the ACT survey data , note: standard errors in parenthesis

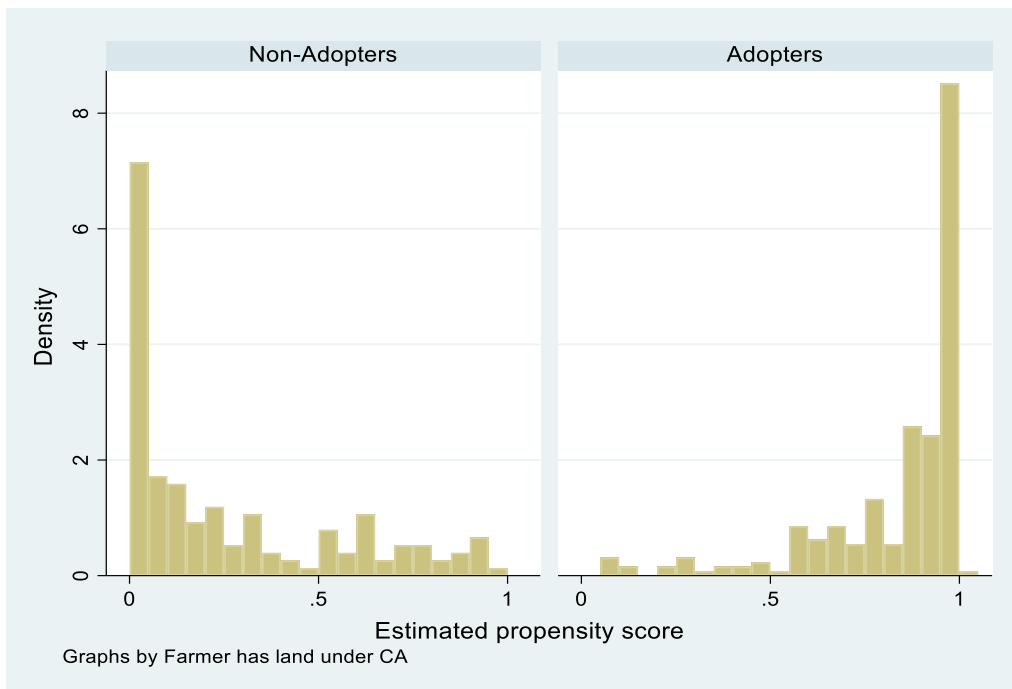
**Table 3. 2: Propensity score estimates of CA adoption**

CA adoption (treat)	Coefficient	Standard error	Z	P> z
Country (1=Kenya, 0 = Tanzania)	-1.608	0.350	-4.600	0.000
<b>Household and plot characteristics</b>				
Age of household (HH) head (years)	-0.005	0.009	-0.530	0.595
Gender of HH head (1=female, 0=otherwise)	0.040	0.209	0.190	0.849
Household size (number of persons)	-0.017	0.029	-0.570	0.57
Total land size (ha)	-0.155	0.096	-1.610	0.107
Land size under cultivation (ha)	0.341	0.168	2.030	0.043
<b>Membership, training and skill acquisition</b>				
Farmer group membership (1=yes, 0=otherwise)	0.478	0.298	1.600	0.109
Had environmental conservation training (1=yes, 0=otherwise)	0.761	0.212	3.590	0.000
Benefited from any CA project (1=yes, 0=otherwise)	1.623	0.240	6.760	0.000
<b>Access to information</b>				
Had contact with extension services (1=yes, 0=otherwise)	0.181	0.325	0.560	0.578
Had information about CA (1=yes, 0=otherwise)	0.243	0.335	0.720	0.469
<b>Institutional services</b>				
Ever accessed credit (1=yes, 0=otherwise)	0.886	0.205	4.330	0.000
Had access to agro-dealer (1=yes, 0=otherwise)	1.364	0.310	4.400	0.000
Constant term	-2.038	0.534	-3.810	0.000
Observations	= 407			
LR chi2	= 276.01			
Prob>chi2	= 0.000			
Pseudo R2	= 0.514			
Log-likelihood	= -130.406			

Source: Computations from the ACT survey data



**Figure 3. 1: Kernel density distribution of estimated propensity scores.**



**Figure 3. 2: Histogram density distribution of estimated propensity scores.**

Consistent with results by Ndah *et al.* (2015), Table 3.2 shows that farmers in Tanzania are more likely to adopt CA practices relative to their Kenyan counterparts. Table 3.2 further shows that the probability of CA adoption increases if the household had prior environmental conservation training and prior benefited from any CA project, findings which are consistent with studies by Esabu & Ngwenya. (2019), Mulimbi *et al.* (2019) and Lovell & Sullivan. (2006). Environmental conservation training and benefiting from a CA project proxy exposure to information about the benefits of CA uptake, which is a causal path to CA adoption. The results further show that the probability of adopting CA increases if households had access to institutional support services such as credit and agro-dealers, results which lend credence to observations by Khonje *et al.* (2015); Kuntashula *et al.*, (2014); Kuntashula & Mungatana (2015) and Rodenburg *et al.* (2020).

We proceeded to use the propensity scores of Tables 3.2 to approximate the average treatment effect of adopting CA on the treated (ATT) with respect to the outcome variables identified in chapter 2 using three matching strategies, for results robustness and consistency: nearest neighbour, kernel, and stratification. Table 3.3 reports the causal effect estimates of adopting CA on agronomic outcomes. Consistent with Rusinamhodzi *et al.*, (2011), Table 3.3 shows that farmers on average perceive CA as having negative and statistically significant impacts on total agricultural yield and total maize production. Rusinamhodzi *et al.*, (2011) contend that CA technologies like mulching could actually reduce yield or productivity due to waterlogging following too much rainfall. Rosenstock *et al.*, (2014) also report negative impacts of CA adoption on yield in Kenya, attributed to a wide range of socioeconomic and biophysical factors that render CA inappropriate for resource-limited smallholders. Total agricultural yield was defined as the overall production for all crops grown by a household per unit area, as such, it is not surprising that it had reduced. This could also be attributed to the reduction of other crops grown as most farmers grow only maize in the study areas.

Table 3. 3 shows that CA adoption had positive and statistically significant impacts on perceived adaptation to climate change and resilience to drought, which is consistent with (Mwango *et al.*, 2016) observation that the ability of mulch to retain moisture enhances adaption to climate change and makes crops drought resilient.

**Table 3. 3: Impact of CA adoption on agronomic outcomes**

Matching algorithm	Treated	Control	ATT	Std. Err.	t -stat
Total agricultural yield					
Nearest neighbour	256	45	-0.117	0.062	1.883
Stratification matching	256	96	-0.105	0.023	4.551
Kernel matching	256	96	-0.108	0.021	5.225
Adaptation to climate change impacts					
Nearest neighbour	256	45	0.523	0.085	6.186
Stratification matching	256	96	0.775	0.095	8.190
Kernel matching	256	96	0.759	0.112	6.796
Resilience to drought					
Nearest neighbour	256	45	0.496	0.063	7.892
Stratification matching	256	96	0.760	0.094	8.046
Kernel matching	256	96	0.741	0.093	7.948
Total maize production					
Nearest neighbour	256	45	0.441	0.086	5.139
Stratification matching	256	96	0.694	0.096	7.249
Kernel matching	256	96	0.678	0.100	6.751

*Source: Computations from the ACT survey data*

Table 3. 4 shows the estimated impact of CA adoption on food security and nutrition outcomes, which are indicators of household wellbeing (Mango, Siziba and Makate, 2017). The results show that CA adoption had a positive and significant impact on perceived food security and number of meals per day. CA adoption however significantly reduces the number of food insecure months. Jumbe and Nyambose, (2016), and Siziba *et al.*, (2019) observe that through increased maize



production, CA adoption enhanced household food security, which increases the frequency of meals eaten per day, and subsequently increases the number of months with food provision.

**Table 3. 4: Impact of CA adoption on food security and nutrition outcomes**

Matching algorithm	Treated	Control	ATT	Std. Err.	t -stat
Food security					
Nearest neighbour	256	45	0.621	0.060	10.432
Stratification matching	256	96	0.873	0.093	9.406
Kernel matching	256	96	0.855	0.090	9.460
Number of meals per day					
Nearest neighbour	256	45	0.617	0.084	7.315
Stratification matching	256	96	0.867	0.94	9.188
Kernel matching	256	96	0.852	0.087	9.819
Number of food insecure months					
Nearest neighbour	256	45	-0.090	0.100	0.902
Stratification matching	256	96	-0.340	0.107	3.169
Kernel matching	256	96	-0.324	0.104	3.122

*Source: Computations from the ACT survey data*

Table 3. 5 presents the impact of CA on perceived economic outcomes. The results show that households perceived CA adoption as having positive and statistically significant impacts on both household income and the ability of households to accumulate productive assets. This could be attributed to the perceived higher maize production earlier reported, as smallholder farmers mostly depend on maize sales for their income which could be used to acquire productive assets. This is consistent with results by Ogada *et al.* (2020) and Micheni *et al.* (2016), who reported positive impacts of CA on income as the pathway through which productive assets are acquired. The results further show a negative and significant impact of CA on perceived production costs, implying that CA reduces production costs. This is consistent with Hobbs (2007) and Hobbs & Gupta (2004),

who reported reduced production cost due to CA technology practice. Finally, households perceived CA as having no impact on their ability to address agricultural calendar bottlenecks.

**Table 3. 5: Impact of CA on economic outcomes**

Matching algorithm	Treated	Control	ATT	Std. Err.	t -stat
Household income					
Nearest neighbour	256	45	0.543	0.062	8.793
Stratification matching	256	96	0.794	0.094	8.435
Kernel matching	256	96	0.777	0.109	7.117
Accumulation of productive assets					
Nearest neighbour	256	45	0.316	0.066	4.814
Stratification matching	256	96	0.569	0.097	5.887
Kernel matching	256	96	0.551	0.104	5.298
Total agricultural production costs					
Nearest neighbour	256	45	-0.359	0.065	5.510
Stratification matching	256	96	-0.623	0.096	6.497
Kernel matching	256	96	-0.604	0.113	5.349
Addressing agricultural calendar bottlenecks					
Nearest neighbour	256	45	-0.047	0.066	0.707
Stratification matching	256	96	-0.311	0.096	1.234
Kernel matching	256	96	-0.292	0.091	1.194

*Source: Computations from the ACT survey data*

The results reported in Table 3. 6 show that farmers perceive CA as having a positive and significant impact on improving gender and social outcomes. We could attribute these results to the relatively higher number of males adopting CA practices, who are also involved in weed

management practices like spraying herbicides, thus reducing labour requirements that would ordinarily be undertaken by women (Pannell, Llewellyn and Corbeels, 2014).

**Table 3. 6: Impact of CA on gender and social outcomes**

Matching algorithm	Treated	Control	ATT	Std. Err.	t -stat
Gender disparities					
Nearest neighbour	256	45	0.355	0.065	5.445
Stratification matching	256	96	0.619	0.096	6.454
Kernel matching	256	96	0.601	0.100	5.992
Social cohesion					
Nearest neighbour	256	45	0.473	0.063	7.461
Stratification matching	256	96	0.726	0.095	7.616
Kernel matching	256	96	0.708	0.087	8.153

Source: Computations from the ACT survey data

The results reported in Table 3. 7 show that smallholder farmers perceive CA as having positive and statistically significant impacts on improving soil health, consistent with many studies that report CA to have reduced soil erosion and improved overall soil quality (e.g. Corbeels *et al.*, 2014; Mwangi *et al.*, 2016; Ndah *et al.*, 2015). The results further show that CA adoption has a positive and significant impact on reducing the forest area cleared per year. We could attribute this result, which is consistent with Kuntashula & Mungatana, (2015) and Kwesiga *et al.*, (1999) who note that modern farming technologies reduce the amount of firewood cut from natural forests, to the high numbers of CA adopters having received skills training in environmental conservation.

**Table 3. 7: Impact of CA on environmental outcomes**

Matching algorithm	Treated	Control	ATT	Std. Err.	t -stat
Soil health					
Nearest neighbour	256	45	0.496	0.063	7.892
Stratification matching	256	96	0.760	0.094	8.047
Kernel matching	256	96	0.741	0.091	8.187
Forest area cleared					
Nearest neighbour	256	45	0.309	0.029	10.668
Stratification matching	256	96	0.307	0.026	11.831
Kernel matching	256	96	0.307	0.030	10.353

Source: Computations from the ACT survey data

### 3.2 Cross-country policy lessons arising from CA adoption category differences.

To draw cross-country lessons for the adoption of CA, we first examined whether farmers from Kenya and Tanzania differ significantly in the variables hypothesized to determine the likelihood of CA adoption (Table 3. 8).

**Table 3. 8: Household descriptive characteristics by country of residence**

Variable	Kenya (N=204)	Tanzania (N=203)	Chi2,  t -value
<b>Household and plot characteristics</b>			
Age of household (HH) head (years)	56.30 (0.75)	48.16 (0.73)	7.815
Gender of HH head (1=female, 0=otherwise)	0.333 (0.35)	0.158 (0.32)	16.94
Education level of HH head (years)	9.294 (0.28)	6.813 (0.15)	7.839
Household size (number of persons)	7.368 (0.24)	6.473 (0.21)	2.753
Total land size (ha)	1.577 (0.07)	2.270 (0.15)	4.077
Land size under cultivation (ha)	0.828 (0.04)	2.005 (0.11)	10.61
<b>Membership, training and skill acquisition</b>			
Member of farmer group (1=yes, 0=otherwise)	0.946 (0.12)	0.625 (0.02)	62.17
Had environmental conservation training (1=yes, 0=otherwise)	0.735 (0.21)	0.433 (0.16)	38.16
Benefitted from any CA project (1=yes, 0=otherwise)	0.78 (0.71)	0.665 (0.52)	7.912
At least moderate mastery of CA technologies (1=yes, 0=otherwise)	0.264 (0.09)	0.611 (0.13)	49.54
<b>Access to information</b>			
Had contact with extension services (1=yes, 0=otherwise)	0.510 (0.06)	0.680 (0.10)	12.20
Had information about CA (1=yes, 0=otherwise)	0.539 (0.41)	0.788 (0.14)	28.24
<b>Institutional services</b>			
Ever accessed credit (1=yes, 0=otherwise)	0.485 (0.03)	0.152 (0.01)	51.77
Had access to agro-dealer (1=yes, 0=otherwise)	0.965 (0.05)	0.576 (0.02)	87.49

Source: Computations from the ACT survey data

Standard errors in parenthesis

All variables in Table 3. 8 show statistically significant differences between smallholder farmers in Kenya and Tanzania. Therefore, we tested whether the country of residence had the same influence on the likelihood of adopting CA as the individual independent variables in equation (1). Using the education level of the household head to illustrate the general testing approach, we followed Ai & Norton ( 2003) to include an interaction term between the education level of the household head and the country of residence (education + country) in the equation that predicts the probability of adopting CA (see equation (5)).

$$\begin{aligned}
 P(CAadopt) = & \beta_0 + \beta_1country + \beta_2(educ + country) + \beta_3age + \beta_4gender + \\
 & \beta_5HHsize + \beta_6totalandsize + \beta_7landcultivatedsize + \beta_8membership + \beta_9evirskill + \\
 & \beta_{10}benftCA + \beta_{11}mastery + \beta_{12}accessexten + \beta_{13}accessCAinfo + \beta_{14}credit + \\
 & \beta_{15}agrodealer + Error\ term
 \end{aligned} \tag{5}$$

The expectation from equation (5) is that  $\beta_1 = \beta_2 = 0$ , if the null hypothesis doesn't hold, we would conclude that country of residence and education level of the household head have differential impacts on the probability of CA adoption. Table 3. 9 reports the probit estimation results of equation (5).

From the results presented in Table 3. 9, we see that the coefficient on country dummy and that of the interaction term are statistically different from zero i.e., significant at 1% (with p-value=0.00). This implies that the impact of the country of residence in determining the probability of CA adoption is different from the impact of education on the probability to adopt CA (i.e.,  $\beta_1 \neq \beta_2 \neq 0$ ). This means that a further analysis on the mean statistics for each variable used for interactions, could help us learn from experiences of either Kenya or Tanzania to inform policy on adoption of CA. Given that smallholder farmers in Tanzania are more likely to adopt CA compared to those in Kenya, and that our data show a lower average level of education for smallholder farmers in Tanzania (Table 3. 8), we conclude that policy makers in Kenya could potentially increase adoption of CA by promoting the technologies among the less educated.

**Table 3. 9: Probit regression of CA adoption with education and country interaction term**

CA adoption (treat)	Coef.	Std Err.	Z	P> z
Country (1=Kenya, Tanzania=0)	-1.688	0.454	-3.720	0.000
Education + country	0.093	0.033	2.820	0.005
<b>Household and plot characteristics</b>				
Age of household (HH) head (years)	0.000	0.011	0.040	0.970
Gender of HH head (1=female, 0=otherwise)	0.322	0.264	1.220	0.223
Household size (number of persons)	0.006	0.034	0.170	0.865
Total land size (ha)	-0.124	0.114	-1.090	0.276
Land size under cultivation (ha)	0.259	0.222	1.160	0.245
<b>Membership, training and skill acquisition</b>				
Member of farmer group (1=yes, 0=otherwise)	0.372	0.364	1.020	0.306
Had environmental conservation training (1=yes, 0=otherwise)	0.679	0.248	2.740	0.006
Benefitted from any CA project (1=yes, 0=otherwise)	1.566	0.279	5.610	0.000
At least moderate mastery of CA technologies (1=yes, 0=otherwise)	1.960	0.319	6.140	0.000
<b>Access to information</b>				
Had contact with extension services (1=yes, 0=otherwise)	0.103	0.373	0.280	0.781
Had information about CA (1=yes, 0=otherwise)	-0.098	0.383	-0.250	0.799
<b>Institutional services</b>				
Ever accessed credit (1=yes, 0=otherwise)	0.838	0.232	3.620	0.000
Had access to agro-dealer (1=yes, 0=otherwise)	1.685	0.377	4.470	0.000
Constant term	-3.618	0.781	-4.630	0.000
Observations	= 407			
LR chi2	= 339.67			
Prob>chi2	= 0.000			
Pseudo R2	= 0.633			
Log-likelihood	= -98.57			

Source: Computations from the ACT survey data

We followed this approach to test for significance of the country dummy in interaction with age of HH head (age + country), gender of HH head (gender + country), HH size (HH size + country), total land size (total land size + country) and land size under cultivation (cultivated land + country).

Further, we tested for its interaction with belonging to a farmer group (membership + country), prior training in environmental conservation (envirskill + country), benefit from CA project (benftdCA + country) and mastery of CA technologies (mastery + country). Lastly, we tested its interaction with whether HH had contact with extension services (access extension + country), had information about CA (information + country), access to credit (credit + country), and access to agro-dealers (agro-dealers+ country). The results for the individual probit results are reported in the appendices, however, we report summaries of the key insights from the probit models below.

**Table 3. 10: Key insights from individual probit models with interaction terms**

Variable	Variables	Coefficient	Std. Err.	Z	P> z
Age	Country dummy	-1.596	0.445	-3.590	0.000
	age + country	0.000	0.011	0.040	0.970
Gender	Country dummy	-1.918	0.550	-3.480	0.000
	gender + country	0.322	0.264	1.220	0.223
Household size	Country dummy	-1.601	0.445	-3.590	0.000
	HHsize + country	0.006	0.034	0.170	0.865
Total land size	Country dummy	-1.471	0.471	-3.120	0.002
	totalandsize + country	-0.124	0.114	-1.090	0.276
Land size under cultivation	Country dummy	-1.854	0.431	-4.300	0.000
	cultivatedland + country	0.259	0.222	1.160	0.245
Farmer group membership	Country dummy	-1.968	0.645	-3.050	0.002
	membership + country	0.372	0.364	1.020	0.306
Environmental Conservation training	Country dummy	-2.275	0.583	-3.900	0.000
	envirskill + country	0.679	0.248	2.740	0.006

**Table 3.10 Continued**

Variable	Variables	Coefficient	Std. Err.	Z	P> z
Benefited from CA	Country dummy	-3.161	0.511	-6.190	0.000
	BenftdCA + country	1.566	0.279	5.610	0.000
Mastery of CA technologies	Country dummy	-3.555	0.533	-6.670	0.000
	Mastery + country	1.960	0.319	6.140	0.000
Access to extension	Country dummy	-1.699	0.570	-2.980	0.003
	Accessexten + country	0.103	0.373	0.280	0.781
Information on CA	Country dummy	-1.498	0.548	-2.730	0.006
	Information + country	-0.098	0.383	-0.250	0.799
Access to credit	Country dummy	-2.434	0.525	-4.640	0.000
	Credit + country	0.838	0.232	3.620	0.000
Access to agro-dealers	Country dummy	-3.280	0.692	-4.740	0.000
	Agro-dealer + country	1.685	0.377	4.470	0.000

*Source: Computations from the ACT survey data*

Our result (Table 3. 10) suggests that the interaction terms of the country dummy with training in environmental conservation, benefit from CA project, moderate mastery of CA technologies, access to credit and access to agro-dealers had statistically significant impacts on the likelihood of adopting a CA technology. Since the proportion of farmers with at least moderate mastery of CA technology is higher in Tanzania relative to Kenya (see Table 3. 8), Kenyan policy makers and promoters of CA technology should focus on increasing mastery of CA technology among the less educated smallholder farmers. Further, our results suggest that the Kenyan promoters of CA should focus on households that have not been exposed to environmental conservation training and those that have not had any benefits from a CA projects. They should also target households who have never had access to credit and agro-dealers among the less educated farmers.



## CHAPTER 4: CONCLUSION

This study comparatively assessed whether conservation agriculture causally improves smallholder farmers welfare in Kenya and Tanzania. Using pooled cross sectional household data from the said countries and applying propensity score matching techniques which controls for self-selection bias, the study shows that CA technologies have diverse consequences or impacts for various selected outputs. Adoption of CA practices enhanced total maize production, number of meals per day, reduced number of insecure months, and improved food security. These outcome variables are proxies for improved household welfare. Adoption of CA also increased household income which subsequently increased the accumulation of productive assets. Other positive impacts of CA were observed for household's resilience to drought and adoption to climate change, reduction in gender disparities, and improvement in social cohesion. Our data also showed that CA had a positive impact on the environment as observed from the causal increase in soil health improvements and reduced forest area cleared per year. However, adoption of CA technology had a negative impact on total agricultural yield and total production cost. The reduced total agricultural yield could be attributed to small portions of land allocated for other crops as most farmers in the said countries grow more maize crop than other crops. The reduced total production cost is arguably attributed to reduced labour needs as CA tend to encourage use of herbicides. CA adoption had no impact on the ability of households to address agricultural calendar bottlenecks.

Our study further found that the likelihood of CA adoption was higher for Tanzania than Kenya. In view of the foregoing, Kenya could potentially increase the adoption of CA by focusing on households that have not yet had environmental conservation training as while as those that have not been exposed to the benefits of CA technology among the less educated. The Kenyan promoters of CA should also enhance access to credit and agro-dealers as well as putting in place measures that will see farmers have at least moderate mastery of CA technology especially among the less educated households. The results give credence to the importance of CA technology in cross-country experiences which show improvement in farmer welfare. Further research should focus on understanding further why Kenya has lower adoption rate compared to Tanzania despite having more educated farmers relative to Tanzania.

In this paper we used pooled OLS as a method for doing policy analysis using interaction terms as a basis for drawing cross country conclusions. We however recognise from the reviews that there is an alternative to doing the policy by doing impact assessment for each country and subsequently using the results from each country to do comparisons to inform the policy analysis. While we acknowledge that this is a potentially plausible method for doing the policy analysis, we leave it as an opportunity for another paper that may wish to use the similar dataset.

## REFERENCES

- Abadie, A. and Imbens, G. W. (2016) 'Matching on the estimated propensity score', *Econometrica*. Wiley Online Library, 84(2), pp. 781–807.
- Ai, C. and Norton, E. C. (2003) 'Interaction terms in logit and probit models', *Economics letters*. Elsevier, 80(1), pp. 123–129.
- Amare, M., Asfaw, S. and Shiferaw, B. (2012) 'Welfare impacts of maize-pigeonpea intensification in Tanzania', *Agricultural Economics*, 43(1), pp. 27–43. doi: 10.1111/j.1574-0862.2011.00563.x.
- Beal, S. J. and Kupzyk, K. A. (2014) 'An introduction to propensity scores: what, when, and how', *The Journal of Early Adolescence*. Sage Publications Sage CA: Los Angeles, CA, 34(1), pp. 66–92.
- Caliendo, M. and Kopeinig, S. (2008) 'Some practical guidance for the implementation of propensity score matching', *Journal of economic surveys*. Wiley Online Library, 22(1), pp. 31–72.
- Corbeels, M., de Graaff, J., Ndah, T. H., Penot, E., Baudron, F., Naudin, K., Andrieu, N., Chirat, G., Schuler, J., Nyagumbo, I., Rusinamhodzi, L., Traore, K., Mzoba, H. D. and Adolwa, I. S. (2014) 'Understanding the impact and adoption of conservation agriculture in Africa: A multi-scale analysis', *Agriculture, Ecosystems and Environment*. Elsevier B.V., 187, pp. 155–170. doi: 10.1016/j.agee.2013.10.011.
- Enfors, E., Barron, J., Makurira, H., Rockström, J. and Tumbo, S. (2011) 'Yield and soil system changes from conservation tillage in dryland farming: A case study from North Eastern Tanzania', *Agricultural Water Management*, 98(11), pp. 1687–1695. doi: <https://doi.org/10.1016/j.agwat.2010.02.013>.
- Esabu, A. and Ngwenya (2019) 'Socio-economic factors influencing adoption of conservation agriculture in moroto district, Uganda', *J. Agric. Ext. Esabu, Ngwenya*, 47(2), pp. 105–117. doi: 10.17159/2413-3221/2019/v47n2a507.

- FAO (2009) ‘Scaling-up Conservation Agriculture in Africa: Strategy and Approaches’, *FAO Sub Regional Office for Eastern Africa (SFE)*, p. 35. Available at: [www.fao.org/ag/ca/doc/conservation.pdf](http://www.fao.org/ag/ca/doc/conservation.pdf).
- Feder, G., Just, R. E. and Zilberman, D. (1985) ‘Adoption of agricultural innovations in developing countries: A survey’, *Economic development and cultural change*. University of Chicago Press, 33(2), pp. 255–298.
- Fleming, W. G. (1970) ‘The Logic of Comparative Social Inquiry. By Adam Przeworski and Henry Teune. (New York: John Wiley and Sons, Inc., 1970. Pp. 153. \$8.50.)’, *American Political Science Review*, 64(4), pp. 1255–1256. doi: 10.2307/1958372.
- Gathiru, K. and Ong, C. (2006) ‘Evolution of land management approaches Two decades of research and development in eastern and southern Africa. ICRAF Working Paper no. 21. Nairobi, Kenya.’, *World Agroforestry Centre*.
- Giller, K. E., Witter, E., Corbeels, M. and Tittonell, P. (2009) ‘Conservation agriculture and smallholder farming in Africa: The heretics’ view’, *Field Crops Research*, 114(1), pp. 23–34. doi: 10.1016/j.fcr.2009.06.017.
- GoK (2017) ‘Capacity building strategy for agriculture’. Nairobi: Government of Kenya, pp. 1–57. Available at: <http://extwprlegs1.fao.org/docs/pdf/ken189996.pdf>.
- Heckman, J. J., Ichimura, H. and Todd, P. (1998) ‘Matching as an econometric evaluation estimator’, *The review of economic studies*. Wiley-Blackwell, 65(2), pp. 261–294.
- Hobbs, P. R. (2007) ‘Paper Presented at International Workshop on Increasing Wheat Yield Potential, CIMMYT, Obregon, Mexico, 20-24 March 2006. Conservation agriculture: What is it and why is it important for future sustainable food production?’, *Journal of Agricultural Science*, 145(2), pp. 127–137. doi: 10.1017/S0021859607006892.
- Hobbs, P. R. and Gupta, R. (2004) ‘Problems and challenges of no-till farming for the rice-wheat systems of the Indo-Gangetic Plains in South Asia’, *Sustainable agriculture and the international rice-wheat system*. CRC Press Boca Raton, FL, pp. 101–118.

- Van Hulst, F. J. and Posthumus, H. (2016) ‘Understanding (non-) adoption of conservation agriculture in Kenya using the reasoned action approach’, *Land Use Policy*. Elsevier, 56, pp. 303–314.
- Jumbe, C. B. L. and Nyambose, W. H. (2016) ‘Does Conservation Agriculture Enhance Household Food Security? Evidence from Smallholder Farmers in Nkhotakota in Malawi’, *Sustainable Agriculture Research*, 5(1) pp 118-128. doi: 10.5539/sar.v5n1p118..
- Kahimba, F. C., Mutabazi, K. D., Tumbo, S. D., Masuki, K. F. and Mbungu, W. B. (2014) ‘Adoption and Scaling-Up of Conservation Agriculture in Tanzania : Case of Arusha and Dodoma Regions’, *Natural Resource*, 5(4), pp. 161–176.
- Kangalawe, R. Y. M., Christiansson, C. and Östberg, W. (2008) ‘Changing land-use patterns and farming strategies in the degraded environment of the Irangi Hills, central Tanzania’, *Agriculture, ecosystems & environment*. Elsevier, 125(1–4), pp. 33–47.
- Kassam, A., Friedrich, T., Shaxson, F. and Pretty, J. (2009) ‘The spread of Conservation Agriculture: justification, sustainability and uptake’, *International Journal of Agricultural Sustainability*. Taylor & Francis, 7(4), pp. 292–320. doi: 10.3763/ijas.2009.0477.
- Kassie, M., Teklewold, H., Marenya, P., Jaleta, M. and Erenstein, O. (2015) ‘Production Risks and Food Security under Alternative Technology Choices in Malawi: Application of a Multinomial Endogenous Switching Regression’, *Journal of Agricultural Economics*, 66(3), pp. 640–659. doi: 10.1111/1477-9552.12099.
- Kaumbutho, P. and Kienzle, J. (2007) Conservation agriculture in Kenya. *Conservation agriculture in Kenya: two case-studies*, Kaumbutho P, Kienzle J (eds). ACT, CIRAD, FAO: Nairobi
- Khandker, S., B. Koolwal, G. and Samad, H. (2009) *Handbook on impact evaluation: quantitative methods and practices*. The World Bank.
- Khonje, M., Manda, J., Alene, A. D. and Kassie, M. (2015) ‘Analysis of Adoption and Impacts of Improved Maize Varieties in Eastern Zambia’, *World Development*. Elsevier Ltd, 66, pp. 695 706-706. doi: 10.1016/j.worlddev.2014.09.008.

- Kinyumu, D. M. (2012) 'Is Conservation Agriculture a Solution to Dry Land Rain-fed Farming? Experiences and Perceptions of Smallholder Farmers in Laikipia District, Kenya', 7, pp. 134–147.
- Kipkemboi, B., Lalit, K. and Richard, K. (2021) 'Climate change and variability in Kenya: a review of impacts on agriculture and food security', *Environment, Development and Sustainability*. Springer Netherlands, 23(1), pp. 23–43. doi: 10.1007/s10668-020-00589-1.
- Kuntashula, E., Chabala, L. M. and Mulenga, B. P. (2014) 'Impact of minimum tillage and crop rotation as climate change adaptation strategies on farmer welfare in smallholder farming systems of Zambia', *Journal of Sustainable Development*, 7(4), pp. 95–110. doi: 10.5539/jsd.v7n4p95.
- Kuntashula, E. and Mungatana, E. (2015) 'Estimating the causal effect of improved fallows on environmental services provision under farmers' field conditions in Chongwe, Zambia', *Environment and Development Economics*, 20(1), pp. 80–100. doi: 10.1017/S1355770X14000011.
- Kwesiga, F. R., Franzel, S., Place, F., Phiri, D. and Simwanza, C. P. (1999) 'Sesbania sesban improved fallows in eastern Zambia: Their inception, development and farmer enthusiasm', *Agroforestry systems*. Springer, 47(1), pp. 49–66.
- Lovell, S. T. and Sullivan, W. C. (2006) 'Environmental benefits of conservation buffers in the United States: Evidence, promise, and open questions', *Agriculture, ecosystems & environment*. Elsevier, 112(4), pp. 249–260.
- Lugandu, S., Kathaku, A., Ngotio, D., Mpanda, M., Dulla, H., Muriuki, J., Mkomwa, S. and Mowo, J. (2011) 'survey on the extent of and factors affecting adoption of conservation agriculture (with trees) by smallholder farmers in Sub-Saharan Africa (unpublished). ICRAF, ACT, SIDA: Nairobi'.
- Makunike, R. E. and Kirsten, J. F. (2018) 'Engagement dynamics in large-scale investments in farmland and implications for smallholder farmers - evidence from Zambia', *African Journal of Agricultural and Resource Economics*, 13(2), pp. 127–139. doi:

10.22004/ag.econ.274734.

- Manda, J., Alene, A. D., Gardebroek, C., Kassie, M. and Tembo, G. (2016) ‘Adoption and Impacts of Sustainable Agricultural Practices on Maize Yields and Incomes: Evidence from Rural Zambia’, *Journal of Agricultural Economics*, 67(1), pp. 130–153. doi: 10.1111/1477-9552.12127.
- Mango, N., Makate, C., Tamene, L., Mponela, P. and Ndengu, G. (2020) ‘Impact of the adoption of conservation practices on cereal consumption in a maize-based farming system in the Chinyanja Triangle, Southern Africa’, *Sustainable Futures*. Elsevier Ltd, 2(February), p. 100014. doi: 10.1016/j.sfr.2020.100014.
- Mango, N., Siziba, S. and Makate, C. (2017) ‘The impact of adoption of conservation agriculture on smallholder farmers’ food security in semi-arid zones of southern Africa’, *Agriculture and Food Security*. BioMed Central, 6(1), pp. 1–8. doi: 10.1186/s40066-017-0109-5.
- Marenya, P. P. and Barrett, C. B. (2007) ‘Household-level determinants of adoption of improved natural resources management practices among smallholder farmers in western Kenya’, *Food Policy*, 32(4), pp. 515–536. doi: 10.1016/j.foodpol.2006.10.002.
- Marenya, P. P., Kassie, M., Jaleta, M., Rahut, D. B. and Erenstein, O. (2017) ‘Predicting minimum tillage adoption among smallholder farmers using micro-level and policy variables’, *Agricultural and Food Economics*. Agricultural and Food Economics, 5(1), pp. 1–22. doi: 10.1186/s40100-017-0081-1.
- Micheni, A. N., Kanampiu, F., Kitonyo, O., Mburu, D. M., Mugai, E. N., Makumbi, D. and Kassie, M. (2016) ‘On-farm experimentation on conservation agriculture in maize-legume based cropping systems in Kenya: water use efficiency and economic impacts’, *Experimental Agriculture*. Cambridge University Press, 52(1), pp. 51–68.
- Mkomwa, S., Mussei, A. and Mwakimbwala, R. (2007) Mbeya District, In *Conservation agriculture as practised in Tanzania: three case-studies*, Shetto R, Owenya M (eds). ACT, CIRAD, FAO: Nairobi; pp.105–146
- Mkwambisi, D. D., Boillat, S., Jew, E. K. K., Steward, P. R., Speranza, C. I. and Dougill, A. J.

- (2019) ‘Can smallholder farmers buffer rainfall variability through conservation agriculture? On-farm practices and maize yields in Kenya and Malawi Can smallholder farmers buffer rainfall variability through conservation agriculture? On-farm practices and maize yields in Kenya and Malawi’, *Environmental Research Letter*, 14 115007 <https://doi.org/10.1088/1748-9326/ab45ad>
- Mulimbi, W., Nalley, L., Dixon, B., Snell, H. and Huang, Q. (2019) ‘Factors Influencing Adoption of Conservation Agriculture in the Democratic Republic of the Congo’, *Journal of Agricultural and Applied Economics*. Cambridge University Press, 51(04), pp. 622–645. doi: 10.1017/aae.2019.25.
- Mwango, S. B., Msanya, B. M., Mtakwa, P. W., Kimaro, D. N., Deckers, J. and Poesen, J. (2016) ‘Effectiveness of mulching under miraba in controlling soil erosion, fertility restoration and crop yield in the Usambara Mountains, Tanzania’, *Land Degradation & Development*. Wiley Online Library, 27(4), pp. 1266–1275.
- Ndah, H. T., Schuler, J., Uthes, S., Zander, P., Triomphe, B., Mkomwa, S. and Corbeels, M. (2015) ‘Adoption Potential for Conservation Agriculture in Africa: A Newly Developed Assessment Approach (QAToCA) Applied in Kenya and Tanzania’, *Land Degradation and Development*, 26(2), pp. 133–141. doi: 10.1002/ldr.2191.
- Ng’ombe, J., Kalinda, T., Tembo, G. and Kuntashula, E. (2014) ‘Econometric analysis of the factors that affect adoption of conservation farming practices by smallholder farmers in Zambia’, *Journal of Sustainable Development*, 7(4), pp. 124–138. doi: 10.5539/jsd.v7n4p124.
- Ngalande, N. (2021) ‘The impact of conservation agriculture adoption on farmer welfare: a comparative assessment of Zambia and Zimbabwe’, Unpublished MSc Agricultural Economics Thesis, Department of Agricultural Economics, Extension and Rural Development. Faculty of Natural and Agricultural Sciences, University of Pretoria, South Africa.
- Ogada, M. J., Rao, E. J. O., Radeny, M., Recha, J. W. and Solomon, D. (2020) ‘Climate-smart agriculture, household income and asset accumulation among smallholder farmers in the



- Nyando basin of Kenya’, *World Development Perspectives*. Elsevier, 18(April), p. 100203. doi: 10.1016/j.wdp.2020.100203.
- Pannell, D. J., Llewellyn, R. S. and Corbeels, M. (2014) ‘The farm-level economics of conservation agriculture for resource-poor farmers’, *Agriculture, ecosystems & environment*. Elsevier, 187, pp. 52–64.
- Pender, J. and Gebremedhin, B. (2008) ‘Determinants of agricultural and land management practices and impacts on crop production and household income in the highlands of Tigray, Ethiopia’, *Journal of African Economies*, 17(3), pp. 395–450. doi: 10.1093/jae/ejm028.
- Rodenburg, J., Büchi, L. and Haggard, J. (2020) ‘Adoption by adaptation: moving from Conservation Agriculture to conservation practices’, *International Journal of Agricultural Sustainability*. Taylor & Francis, pp. 1–19. doi: 10.1080/14735903.2020.1785734.
- Rosenbaum, P. R. and Rubin, D. B. (1983) ‘The central role of the propensity score in observational studies for causal effects’, *Biometrika*. Oxford University Press, 70(1), pp. 41–55.
- Rosenstock, T. S., Mpanda, M., Rioux, J., Aynekulu, E., Kimaro, A. A., Neufeldt, H., Shepherd, K. D. and Luedeling, E. (2014) ‘Targeting conservation agriculture in the context of livelihoods and landscapes’, *Agriculture, Ecosystems & Environment*. Elsevier, 187, pp. 47–51.
- Rubin, D. B. (1974) ‘Estimating causal effects of treatments in randomized and nonrandomized studies.’, *Journal of educational Psychology*. American Psychological Association, 66(5), p. 688.
- Rusinamhodzi, L., Corbeels, M., Van Wijk, M. T., Rufino, M. C., Nyamangara, J. and Giller, K. E. (2011) ‘A meta-analysis of long-term effects of conservation agriculture on maize grain yield under rain-fed conditions’, *Agronomy for sustainable development*. Springer, 31(4), p. 657.
- Shetto, R. and Owenya, M. (2007) *Conservation agriculture as practised in Tanzania: Three case studies: Arumeru district, Karatu district, Mbeya district*. ACT, FAO, CIRAD, RELMA.

- Siziba, S., Nyikahadzoi, K., Makate, C. and Mango, N. (2019) ‘Impact of conservation agriculture on maize yield and food security: Evidence from smallholder farmers in Zimbabwe’, *African Journal of Agricultural and Resource Economics*, 14(311-2020–246), pp. 89–105.
- Stevenson, J. R., Serraj, R. and Cassman, K. G. (2014) ‘Evaluating conservation agriculture for small-scale farmers in Sub-Saharan Africa and South Asia’, *Agriculture, Ecosystems and Environment*, 187(July 2013), pp. 1–10. doi: 10.1016/j.agee.2014.01.018.
- Tambo, J. A. and Mockshell, J. (2018) ‘Differential Impacts of Conservation Agriculture Technology Options on Household Income in Sub-Saharan Africa’, *Ecological Economics*. Elsevier, 151(April), pp. 95–105. doi: 10.1016/j.ecolecon.2018.05.005.
- Tittonell, P., Scopel, E., Andrieu, N., Posthumus, H., Mapfumo, P. and Corbeels, M. (2012) ‘Field Crops Research Agroecology-based aggradation-conservation agriculture ( ABACO ): Targeting innovations to combat soil degradation and food insecurity in semi-arid Africa’, *Field Crops Research*. Elsevier B.V., 132, pp. 168–174. doi: 10.1016/j.fcr.2011.12.011.
- URT United Republic of Tanzania (2001) *Agricultural sector development strategy, Tanzania Government*. Dar es Salaam. Available at: <http://www.tzonline.org/pdf/agriculturalsectordevelopmentstrategy.pdf>.
- URT United Republic of Tanzania (2003) ‘Agricultural sector development programme: framework and process document. Final draft. Dar es Salaam: Tanzania Government.’ Available at: [https://tanzania.go.tz/egov\\_uploads/documents/ASDP\\_FINAL\\_25\\_05\\_06\\_\(2\)\\_sw.pdf](https://tanzania.go.tz/egov_uploads/documents/ASDP_FINAL_25_05_06_(2)_sw.pdf).
- Winters, P., Salazar, L. and Maffioli, A. (2010) ‘Designing impact evaluations for agricultural projects’, *Inter-American Development Bank, Washington, DC*, 14, p. 2012. Available at: [https://publications.iadb.org/bitstream/handle/11319/1956/Designing Impact Evaluations%0A for Agricultural Projects.pdf?sequence=1](https://publications.iadb.org/bitstream/handle/11319/1956/Designing_Impact_Evaluations%0A_for_Agricultural_Projects.pdf?sequence=1).

## APPENDICES

**Table A1: Probit regression of CA adoption with age and country interaction term**

CA adoption (treat)	Coef.	Std Err.	Z	P> z
Country (1=Kenya: Tanzania=0)	-1.596	0.445	-3.590	0.000
Age + country	0.000	0.011	0.040	0.970
<b>Household and plot characteristics</b>				
Gender of HH head (1=female: 0=otherwise)	0.322	0.264	1.220	0.223
Education level of HH head (years)	0.093	0.033	2.820	0.005
Household size (number of persons)	0.006	0.034	0.170	0.865
Total land size (ha)	-0.124	0.114	-1.090	0.276
Land size under cultivation (ha)	0.259	0.222	1.160	0.245
<b>Membership, training and skill acquisition</b>				
Member of farmer group (1=yes: 0=otherwise)	0.372	0.364	1.020	0.306
Had environmental conservation training (1=yes: 0=otherwise)	0.679	0.248	2.740	0.006
Benefitted from any CA project (1=yes: 0=otherwise)	1.566	0.279	5.610	0.000
At least moderate mastery of CA technologies (1=yes: 0=otherwise)	1.960	0.319	6.140	0.000
<b>Access to information</b>				
Had contact with extension services (1=yes: 0=otherwise)	0.103	0.373	0.280	0.781
Had information about CA (1=yes: 0=otherwise)	-0.098	0.383	-0.250	0.799
<b>Institutional services</b>				
Ever accessed credit (1=yes: 0=otherwise)	0.838	0.232	3.620	0.000
Had access to agro-dealer (1=yes: 0=otherwise)	1.685	0.377	4.470	0.000
Constant term	-3.618	0.781	-4.630	0.000
Observations	= 407			
LR chi2	= 339.67			
Prob>chi2	= 0.000			
Pseudo R2	= 0.633			
Log-likelihood	= -98.57			

Source: Computations from the ACT survey data

**Table A2: Probit regression of CA adoption with gender and country interaction term**

CA adoption (treat)	Coef.	Std Err.	Z	P> z
Country (1=Kenya: Tanzania=0)	-1.918	0.550	-3.480	0.000
Gender + country	0.322	0.264	1.220	0.223
<b>Household and plot characteristics</b>				
Age of household (HH) head (years)	0.000	0.011	0.040	0.970
Education level of HH head (years)	0.093	0.033	2.820	0.005
Household size (number of persons)	0.006	0.034	0.170	0.865
Total land size (ha)	-0.124	0.114	-1.090	0.276
Land size under cultivation (ha)	0.259	0.222	1.160	0.245
<b>Membership, training and skill acquisition</b>				
Member of farmer group (1=yes: 0=otherwise)	0.372	0.364	1.020	0.306
Had environmental conservation training (1=yes: 0=otherwise)	0.679	0.248	2.740	0.006
Benefitted from any CA project (1=yes: 0=otherwise)	1.566	0.279	5.610	0.000
At least moderate mastery of CA technologies (1=yes: 0=otherwise)	1.960	0.319	6.140	0.000
<b>Access to information</b>				
Had contact with extension services (1=yes: 0=otherwise)	0.103	0.373	0.280	0.781
Had information about CA (1=yes: 0=otherwise)	-0.098	0.383	-0.250	0.799
<b>Institutional services</b>				
Ever accessed credit (1=yes: 0=otherwise)	0.838	0.232	3.620	0.000
Had access to agro-dealer (1=yes: 0=otherwise)	1.685	0.377	4.470	0.000
Constant term	-3.618	0.781	-4.630	0.000
Observations	= 407			
LR chi2	= 339.67			
Prob>chi2	= 0.000			
Pseudo R2	= 0.633			
Log-likelihood	= -98.57			

Source: Computations from the ACT survey data

**Table A3: Probit regression of CA adoption with total land size and country interaction term**

CA adoption (treat)	Coef.	Std Err.	Z	P> z
Country (1=Kenya: Tanzania=0)	-1.471	0.471	-3.120	0.002
total land size + country	-0.124	0.114	-1.090	0.276
<b>Household and plot characteristics</b>				
Age of household (HH) head (years)	0.000	0.011	0.040	0.970
Gender of HH head (1=female: 0=otherwise)	0.322	0.264	1.220	0.223
Education level of HH head (years)	0.093	0.033	2.820	0.005
Household size (number of persons)	0.006	0.034	0.170	0.865
Land size under cultivation (ha)	0.259	0.222	1.160	0.245
<b>Membership, training and skill acquisition</b>				
Member of farmer group (1=yes: 0=otherwise)	0.372	0.364	1.020	0.306
Had environmental conservation training (1=yes: 0=otherwise)	0.679	0.248	2.740	0.006
Benefitted from any CA project (1=yes: 0=otherwise)	1.566	0.279	5.610	0.000
At least moderate mastery of CA technologies (1=yes: 0=otherwise)	1.960	0.319	6.140	0.000
<b>Access to information</b>				
Had contact with extension services (1=yes: 0=otherwise)	0.103	0.373	0.280	0.781
Had information about CA (1=yes: 0=otherwise)	-0.098	0.383	-0.250	0.799
<b>Institutional services</b>				
Ever accessed credit (1=yes: 0=otherwise)	0.838	0.232	3.620	0.000
Had access to agro-dealer (1=yes: 0=otherwise)	1.685	0.377	4.470	0.000
Constant term	-3.618	0.781	-4.630	0.000
Observations	= 407			
LR chi2	= 339.67			
Prob>chi2	= 0.000			
Pseudo R2	= 0.633			
Log-likelihood	= -98.57			

Source: Computations from the ACT survey data

**Table A4: Probit regression of CA adoption with cultivated land and country interaction term**

<b>CA adoption (treat)</b>	<b>Coef.</b>	<b>Std Err.</b>	<b>Z</b>	<b>P&gt; z </b>
Country (1=Kenya: Tanzania=0)	-1.854	0.431	-4.300	0.000
Cultivated land + country	0.259	0.222	1.160	0.245
<b>Household and plot characteristics</b>				
Age of household (HH) head (years)	0.000	0.011	0.040	0.970
Gender of HH head (1=female: 0=otherwise)	0.322	0.264	1.220	0.223
Education level of HH head (years)	0.093	0.033	2.820	0.005
Household size (number of persons)	0.006	0.034	0.170	0.865
Total land size (ha)	-0.124	0.114	-1.090	0.276
<b>Membership, training and skill acquisition</b>				
Member of farmer group (1=yes: 0=otherwise)	0.372	0.364	1.020	0.306
Had environmental conservation training (1=yes: 0=otherwise)	0.679	0.248	2.740	0.006
Benefitted from any CA project (1=yes: 0=otherwise)	1.566	0.279	5.610	0.000
At least moderate mastery of CA technologies (1=yes: 0=otherwise)	1.960	0.319	6.140	0.000
<b>Access to information</b>				
Had contact with extension services (1=yes: 0=otherwise)	0.103	0.373	0.280	0.781
Had information about CA (1=yes: 0=otherwise)	-0.098	0.383	-0.250	0.799
<b>Institutional services</b>				
Ever accessed credit (1=yes: 0=otherwise)	0.838	0.232	3.620	0.000
Had access to agro-dealer (1=yes: 0=otherwise)	1.685	0.377	4.470	0.000
Constant term	-3.618	0.781	-4.630	0.000
Observations	= 407			
LR chi2	= 339.67			
Prob>chi2	= 0.000			
Pseudo R2	= 0.633			
Log-likelihood	= -98.57			

Source: Computations from the ACT survey data

**Table A5: Probit regression of CA adoption with group membership and country interaction term**

<b>CA adoption (treat)</b>	<b>Coef.</b>	<b>Std Err.</b>	<b>Z</b>	<b>P&gt; z </b>
Country (1=Kenya: Tanzania=0)	-1.968	0.645	-3.050	0.002
Group membership + country	0.372	0.364	1.020	0.306
<b>Household and plot characteristics</b>				
Age of household (HH) head (years)	0.000	0.011	0.040	0.970
Gender of HH head (1=female: 0=otherwise)	0.322	0.264	1.220	0.223
Education level of HH head (years)	0.093	0.033	2.820	0.005
Household size (number of persons)	0.006	0.034	0.170	0.865
Total land size (ha)	-0.124	0.114	-1.090	0.276
Land size under cultivation (ha)	0.259	0.222	1.160	0.245
<b>Membership, training and skill acquisition</b>				
Had environmental conservation training (1=yes: 0=otherwise)	0.679	0.248	2.740	0.006
Benefitted from any CA project (1=yes: 0=otherwise)	1.566	0.279	5.610	0.000
At least moderate mastery of CA technologies (1=yes: 0=otherwise)	1.960	0.319	6.140	0.000
<b>Access to information</b>				
Had contact with extension services (1=yes: 0=otherwise)	0.103	0.373	0.280	0.781
Had information about CA (1=yes: 0=otherwise)	-0.098	0.383	-0.250	0.799
<b>Institutional services</b>				
Ever accessed credit (1=yes: 0=otherwise)	0.838	0.232	3.620	0.000
Had access to agro-dealer (1=yes: 0=otherwise)	1.685	0.377	4.470	0.000
Constant term	-3.618	0.781	-4.630	0.000
Observations	= 407			
LR chi2	= 339.67			
Prob>chi2	= 0.000			
Pseudo R2	= 0.633			
Log-likelihood	= -98.57			

Source: Computations from the ACT survey data

**Table A6: Probit regression of CA adoption with information and country interaction term**

<b>CA adoption (treat)</b>	<b>Coef.</b>	<b>Std Err.</b>	<b>Z</b>	<b>P&gt; z </b>
Country (1=Kenya: Tanzania=0)	-1.498	0.548	-2.730	0.006
Information + country	-0.098	0.383	-0.250	0.799
<b>Household and plot characteristics</b>				
Age of household (HH) head (years)	0.000	0.011	0.040	0.970
Gender of HH head (1=female: 0=otherwise)	0.322	0.264	1.220	0.223
Education level of HH head (years)	0.093	0.033	2.820	0.005
Household size (number of persons)	0.006	0.034	0.170	0.865
Total land size (ha)	-0.124	0.114	-1.090	0.276
Land size under cultivation (ha)	0.259	0.222	1.160	0.245
<b>Membership, training and skill acquisition</b>				
Member of farmer group (1=yes: 0=otherwise)	0.372	0.364	1.020	0.306
Had environmental conservation training (1=yes: 0=otherwise)	0.679	0.248	2.740	0.006
Benefitted from any CA project (1=yes: 0=otherwise)	1.566	0.279	5.610	0.000
At least moderate mastery of CA technologies (1=yes: 0=otherwise)	1.960	0.319	6.140	0.000
<b>Access to information</b>				
Had contact with extension services (1=yes: 0=otherwise)	0.103	0.373	0.280	0.781
<b>Institutional services</b>				
Ever accessed credit (1=yes: 0=otherwise)	0.838	0.232	3.620	0.000
Had access to agro-dealer (1=yes: 0=otherwise)	1.685	0.377	4.470	0.000
Constant term	-3.618	0.781	-4.630	0.000
Observations	= 407			
LR chi2	= 339.67			
Prob>chi2	= 0.000			
Pseudo R2	= 0.633			
Log-likelihood	= -98.57			

Source: Computations from the ACT survey data



**Table A7: Probit regression of CA adoption with access to extension and country interaction**

**term**

CA adoption (treat)	Coef.	Std Err.	Z	P> z
Country (1=Kenya: Tanzania=0)	-1.699	0.570	-2.980	0.003
Access to extension + country	0.103	0.373	0.280	0.781
<b>Household and plot characteristics</b>				
Age of household (HH) head (years)	0.000	0.011	0.040	0.970
Gender of HH head (1=female: 0=otherwise)	0.322	0.264	1.220	0.223
Education level of HH head (years)	0.093	0.033	2.820	0.005
Household size (number of persons)	0.006	0.034	0.170	0.865
Total land size (ha)	-0.124	0.114	-1.090	0.276
Land size under cultivation (ha)	0.259	0.222	1.160	0.245
<b>Membership, training and skill acquisition</b>				
Member of farmer group (1=yes: 0=otherwise)	0.372	0.364	1.020	0.306
Had environmental conservation training (1=yes: 0=otherwise)	0.679	0.248	2.740	0.006
Benefitted from any CA project (1=yes: 0=otherwise)	1.566	0.279	5.610	0.000
At least moderate mastery of CA technologies (1=yes: 0=otherwise)	1.960	0.319	6.140	0.000
<b>Access to information</b>				
Had information about CA (1=yes: 0=otherwise)	-0.098	0.383	-0.250	0.799
<b>Institutional services</b>				
Ever accessed credit (1=yes: 0=otherwise)	0.838	0.232	3.620	0.000
Had access to agro-dealer (1=yes: 0=otherwise)	1.685	0.377	4.470	0.000
Constant term	-3.618	0.781	-4.630	0.000
Observations	= 407			
LR chi2	= 339.67			
Prob>chi2	= 0.000			
Pseudo R2	= 0.633			
Log-likelihood	= -98.57			

Source: Computations from the ACT survey data

**Table A8: Probit regression of CA adoption with household size and country interaction term**

CA adoption (treat)	Coef.	Std Err.	Z	P> z
Country (1=Kenya: Tanzania=0)	-1.601	0.445	-3.590	0.000
HH size + country	0.006	0.034	0.170	0.865
<b>Household and plot characteristics</b>				
Age of household (HH) head (years)	0.000	0.011	0.040	0.970
Gender of HH head (1=female: 0=otherwise)	0.322	0.264	1.220	0.223
Education level of HH head (years)	0.093	0.033	2.820	0.005
Total land size (ha)	-0.124	0.114	-1.090	0.276
Land size under cultivation (ha)	0.259	0.222	1.160	0.245
<b>Membership, training and skill acquisition</b>				
Member of farmer group (1=yes: 0=otherwise)	0.372	0.364	1.020	0.306
Had environmental conservation training (1=yes: 0=otherwise)	0.679	0.248	2.740	0.006
Benefitted from any CA project (1=yes: 0=otherwise)	1.566	0.279	5.610	0.000
At least moderate mastery of CA technologies (1=yes: 0=otherwise)	1.960	0.319	6.140	0.000
<b>Access to information</b>				
Had contact with extension services (1=yes: 0=otherwise)	0.103	0.373	0.280	0.781
Had information about CA (1=yes: 0=otherwise)	-0.098	0.383	-0.250	0.799
<b>Institutional services</b>				
Ever accessed credit (1=yes: 0=otherwise)	0.838	0.232	3.620	0.000
Had access to agro-dealer (1=yes: 0=otherwise)	1.685	0.377	4.470	0.000
Constant term	-3.618	0.781	-4.630	0.000
Observations	= 407			
LR chi2	= 339.67			
Prob>chi2	= 0.000			
Pseudo R2	= 0.633			
Log-likelihood	= -98.57			

Source: Computations from the ACT survey data

**Table A9: Probit regression of CA adoption with benefited from CA Project and country interaction term**

CA adoption (treat)	Coef.	Std Err.	Z	P> z
Country (1=Kenya: Tanzania=0)	-3.161	0.511	-6.190	0.000
Benefited from CA Project + country	1.566	0.279	5.610	0.000
<b>Household and plot characteristics</b>				
Age of household (HH) head (years)	0.000	0.011	0.040	0.970
Gender of HH head (1=female: 0=otherwise)	0.322	0.264	1.220	0.223
Education level of HH head (years)	0.093	0.033	2.820	0.005
Household size (number of persons)	0.006	0.034	0.170	0.865
Total land size (ha)	-0.124	0.114	-1.090	0.276
Land size under cultivation (ha)	0.259	0.222	1.160	0.245
<b>Membership, training and skill acquisition</b>				
Member of farmer group (1=yes: 0=otherwise)	0.372	0.364	1.020	0.306
Had environmental conservation training (1=yes: 0=otherwise)	0.679	0.248	2.740	0.006
At least moderate mastery of CA technologies (1=yes: 0=otherwise)	1.960	0.319	6.140	0.000
<b>Access to information</b>				
Had contact with extension services (1=yes: 0=otherwise)	0.103	0.373	0.280	0.781
Had information about CA (1=yes: 0=otherwise)	-0.098	0.383	-0.250	0.799
<b>Institutional services</b>				
Ever accessed credit (1=yes: 0=otherwise)	0.838	0.232	3.620	0.000
Had access to agro-dealer (1=yes: 0=otherwise)	1.685	0.377	4.470	0.000
Constant term	-3.618	0.781	-4.630	0.000
Observations	= 407			
LR chi2	= 339.67			
Prob>chi2	= 0.000			
Pseudo R2	= 0.633			
Log-likelihood	= -98.57			

Source: Computations from the ACT survey data

**Table A10: Probit regression of CA adoption with credit and country interaction term**

<b>CA adoption (treat)</b>	<b>Coef.</b>	<b>Std Err.</b>	<b>Z</b>	<b>P&gt; z </b>
Country (1=Kenya: Tanzania=0)	-2.434	0.525	-4.640	0.000
Credit + country	0.838	0.232	3.620	0.000
<b>Household and plot characteristics</b>				
Age of household (HH) head (years)	0.000	0.011	0.040	0.970
Gender of HH head (1=female: 0=otherwise)	0.322	0.264	1.220	0.223
Education level of HH head (years)	0.093	0.033	2.820	0.005
Household size (number of persons)	0.006	0.034	0.170	0.865
Total land size (ha)	-0.124	0.114	-1.090	0.276
Land size under cultivation (ha)	0.259	0.222	1.160	0.245
<b>Membership, training and skill acquisition</b>				
Member of farmer group (1=yes: 0=otherwise)	0.372	0.364	1.020	0.306
Had environmental conservation training (1=yes: 0=otherwise)	0.679	0.248	2.740	0.006
Benefitted from any CA project (1=yes: 0=otherwise)	1.566	0.279	5.610	0.000
At least moderate mastery of CA technologies (1=yes: 0=otherwise)	1.960	0.319	6.140	0.000
<b>Access to information</b>				
Had contact with extension services (1=yes: 0=otherwise)	0.103	0.373	0.280	0.781
Had information about CA (1=yes: 0=otherwise)	-0.098	0.383	-0.250	0.799
<b>Institutional services</b>				
Had access to agro-dealer (1=yes: 0=otherwise)	1.685	0.377	4.470	0.000
Constant term	-3.618	0.781	-4.630	0.000
Observations	= 407			
LR chi2	= 339.67			
Prob>chi2	= 0.000			
Pseudo R2	= 0.633			
Log-likelihood	= -98.57			

Source: Computations from the ACT survey data

**Table A10: Probit regression of CA adoption with mastery of CA and country interaction term**

CA adoption (treat)	Coef.	Std Err.	Z	P> z
Country (1=Kenya: Tanzania=0)	-3.555	0.533	-6.670	0.000
Mastery of CA + country	1.960	0.319	6.140	0.000
<b>Household and plot characteristics</b>				
Age of household (HH) head (years)	0.000	0.011	0.040	0.970
Gender of HH head (1=female: 0=otherwise)	0.322	0.264	1.220	0.223
Education level of HH head (years)	0.093	0.033	2.820	0.005
Household size (number of persons)	0.006	0.034	0.170	0.865
Total land size (ha)	-0.124	0.114	-1.090	0.276
Land size under cultivation (ha)	0.259	0.222	1.160	0.245
<b>Membership, training and skill acquisition</b>				
Member of farmer group (1=yes: 0=otherwise)	0.372	0.364	1.020	0.306
Had environmental conservation training (1=yes: 0=otherwise)	0.679	0.248	2.740	0.006
Benefitted from any CA project (1=yes: 0=otherwise)	1.566	0.279	5.610	0.000
<b>Access to information</b>				
Had contact with extension services (1=yes: 0=otherwise)	0.103	0.373	0.280	0.781
Had information about CA (1=yes: 0=otherwise)	-0.098	0.383	-0.250	0.799
<b>Institutional services</b>				
Ever accessed credit (1=yes: 0=otherwise)	0.838	0.232	3.620	0.000
Had access to agro-dealer (1=yes: 0=otherwise)	1.685	0.377	4.470	0.000
Constant term	-3.618	0.781	-4.630	0.000
Observations	= 407			
LR chi2	= 339.67			
Prob>chi2	= 0.000			
Pseudo R2	= 0.633			
Log-likelihood	= -98.57			

Source: Computations from the ACT survey data

**Table A11: Probit regression of CA adoption with agro-dealer and country interaction term**

<b>CA adoption (treat)</b>	<b>Coef.</b>	<b>Std Err.</b>	<b>Z</b>	<b>P&gt; z </b>
Country (1=Kenya: Tanzania=0)	-3.280	0.692	-4.740	0.000
Agro-dealer + country	1.685	0.377	4.470	0.000
<b>Household and plot characteristics</b>				
Age of household (HH) head (years)	0.000	0.011	0.040	0.970
Gender of HH head (1=female: 0=otherwise)	0.322	0.264	1.220	0.223
Education level of HH head (years)	0.093	0.033	2.820	0.005
Household size (number of persons)	0.006	0.034	0.170	0.865
Total land size (ha)	-0.124	0.114	-1.090	0.276
Land size under cultivation (ha)	0.259	0.222	1.160	0.245
<b>Membership, training and skill acquisition</b>				
Member of farmer group (1=yes: 0=otherwise)	0.372	0.364	1.020	0.306
Had environmental conservation training (1=yes: 0=otherwise)	0.679	0.248	2.740	0.006
Benefitted from any CA project (1=yes: 0=otherwise)	1.566	0.279	5.610	0.000
At least moderate mastery of CA technologies (1=yes: 0=otherwise)	1.960	0.319	6.140	0.000
<b>Access to information</b>				
Had contact with extension services (1=yes: 0=otherwise)	0.103	0.373	0.280	0.781
Had information about CA (1=yes: 0=otherwise)	-0.098	0.383	-0.250	0.799
<b>Institutional services</b>				
Ever accessed credit (1=yes: 0=otherwise)	0.838	0.232	3.620	0.000
Constant term	-3.618	0.781	-4.630	0.000
Observations	= 407			
LR chi2	= 339.67			
Prob>chi2	= 0.000			
Pseudo R2	= 0.633			
Log-likelihood	= -98.57			

Source: Computations from the ACT survey data

**Table A12: Probit regression of CA adoption with Environmental Conservation training and country interaction term**

CA adoption (treat)	Coef.	Std Err.	Z	P> z
Country (1=Kenya, Tanzania=0)	-2.275	0.583	-3.900	0.000
Environmental Conservation training + country	0.679	0.248	2.740	0.006
<b>Household and plot characteristics</b>				
Age of household (HH) head (years)	0.000	0.011	0.040	0.970
Gender of HH head (1=female: 0=otherwise)	0.322	0.264	1.220	0.223
Education level of HH head (years)	0.093	0.033	2.820	0.005
Household size (number of persons)	0.006	0.034	0.170	0.865
Total land size (ha)	-0.124	0.114	-1.090	0.276
Land size under cultivation (ha)	0.259	0.222	1.160	0.245
<b>Membership, training and skill acquisition</b>				
Member of farmer group (1=yes: 0=otherwise)	0.372	0.364	1.020	0.306
Benefitted from any CA project (1=yes: 0=otherwise)	1.566	0.279	5.610	0.000
At least moderate mastery of CA technologies (1=yes: 0=otherwise)	1.960	0.319	6.140	0.000
<b>Access to information</b>				
Had contact with extension services (1=yes: 0=otherwise)	0.103	0.373	0.280	0.781
Had information about CA (1=yes: 0=otherwise)	-0.098	0.383	-0.250	0.799
<b>Institutional services</b>				
Ever accessed credit (1=yes: 0=otherwise)	0.838	0.232	3.620	0.000
Had access to agro-dealer (1=yes: 0=otherwise)	1.685	0.377	4.470	0.000
Constant term	-3.618	0.781	-4.630	0.000
Observations	= 407			
LR chi2	= 339.67			
Prob>chi2	= 0.000			
Pseudo R2	= 0.633			

Log-likelihood = -98.57

Source: Computations from the ACT survey data

### A13. Study questionnaire



**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 labor; e. Remittances;  
f. Employment; g. Others (specify).....

**SECTION B: EMPOWERMENT**

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

B2. If yes, please provide the following information.

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

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

(a) .....

(b).....

(c) .....

**SECTION C: ADOPTION OF TECHNOLOGIES**

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

Area under cultivation (hectares) \_\_\_\_\_

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?*

---



---



---

**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?

---



---



---



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 <u>on one hectare</u>		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 (subsidised)	
	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?	cash saving      livestock investments
<i>(tick all appropriate options)</i>	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

