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

By

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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: 20th May 2021

DEDICATION

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

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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.

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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 Agro-ecology 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 Kolero, 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 though 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:

$$E(Y_1 - Y_0 \backslash T = 1) \tag{1}$$

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.

$$Y_0 \coprod T \backslash (X) \qquad (2)$$

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:

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

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.

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

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
Household and plot characteristics			
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
Membership, training and skills acquisition			
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
Access to information			
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
Institutional services			
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
Household and plot characteristics				
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
Membership, training and skill acquisition				
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
Access to information				
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
Institutional services				
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

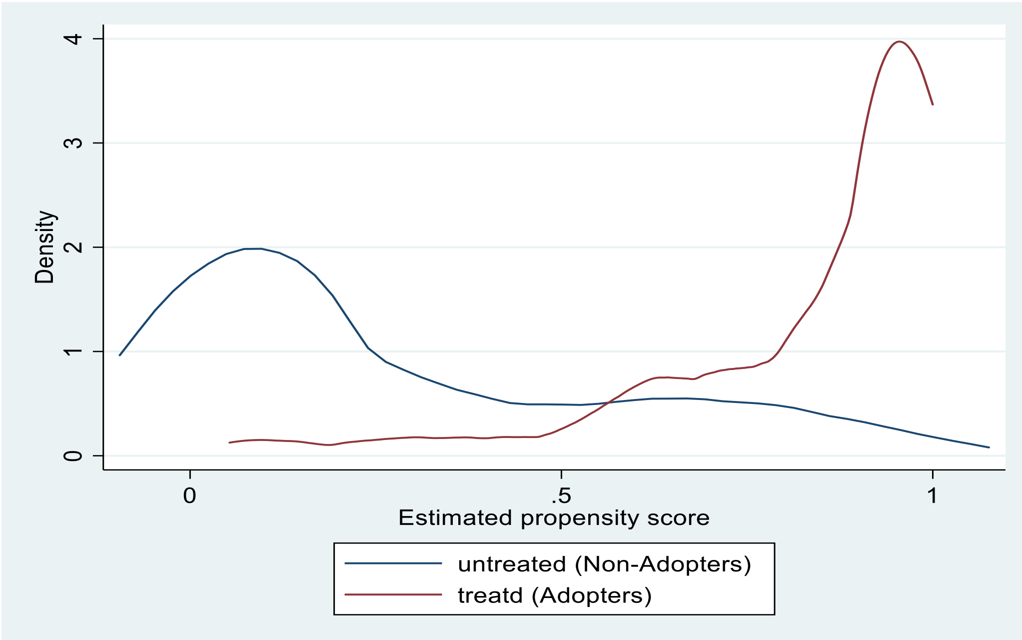

Figure 3. 1: Kernel density distribution of estimated propensity scores.

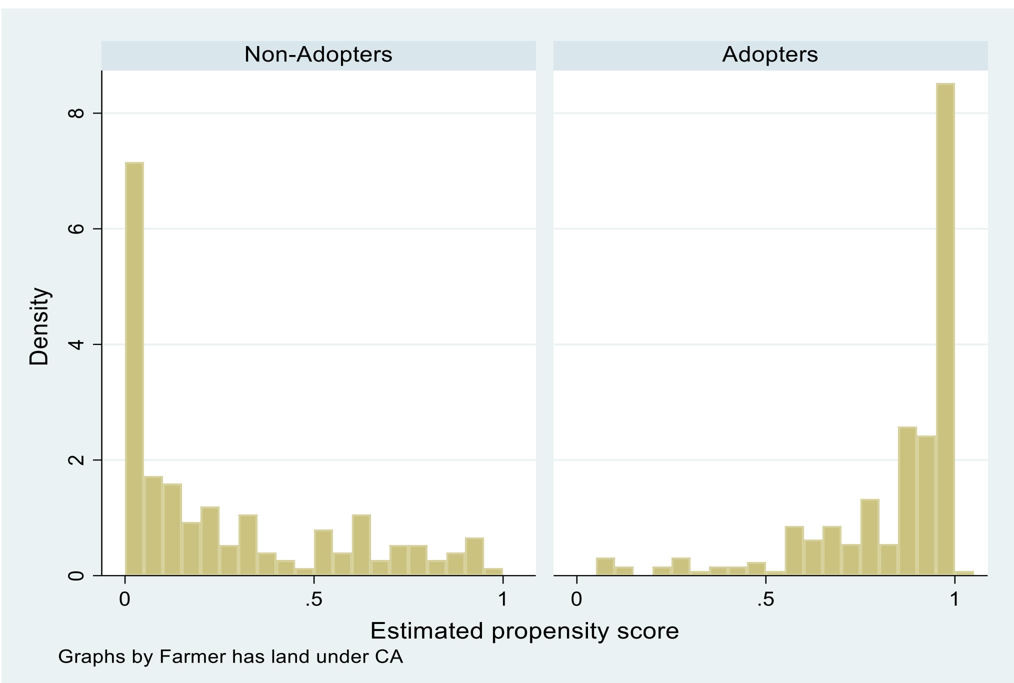

Figure 3. 2: Histogram density distribution of estimated propensity scores.

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 consisted 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; Mwango *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
Household and plot characteristics			
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
Membership, training and skill acquisition			
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
Access to information			
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
Institutional services			
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)).

$$P(CAadopt) = \beta_0 + \beta_1 country + \beta_2(educ + country) + \beta_3 age + \beta_4 gender + \beta_5 HHsize + \beta_6 totalandsize + \beta_7 landcultivatedsize + \beta_8 membership + \beta_9 evirskill + \beta_{10} benftCA + \beta_{11}\text{mastery} + \beta_{12}\text{accessexten} + \beta_{13}\text{accessCAinfo} + \beta_{14} credit + \beta_{15} agrodealer + Error\ term \qquad (5)$$

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
Household and plot characteristics				
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
Membership, training and skill acquisition				
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
Access to information				
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
Institutional services				
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.

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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
Household and plot characteristics				
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
Membership, training and skill acquisition				
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
Access to information				
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
Institutional services				
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

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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
Household and plot characteristics				
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
Membership, training and skill acquisition				
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
Access to information				
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
Institutional services				
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
Household and plot characteristics				
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
Membership, training and skill acquisition				
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
Access to information				
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
Institutional services				
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

CA adoption (treat)	Coef.	Std Err.	Z	P>|z|
Country (1=Kenya: Tanzania=0)	-1.854	0.431	-4.300	0.000
Cultivated land + country	0.259	0.222	1.160	0.245
Household and plot characteristics				
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
Membership, training and skill acquisition				
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
Access to information				
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
Institutional services				
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

CA adoption (treat)	**Coef.**	**Std Err.**	**Z**	**P>|z|**
Country (1=Kenya: Tanzania=0)	-1.968	0.645	-3.050	0.002
Group membership + country	0.372	0.364	1.020	0.306
Household and plot characteristics				
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
Membership, training and skill acquisition				
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
Access to information				
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
Institutional services				
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

CA adoption (treat)	**Coef.**	**Std Err.**	**Z**	**P>|z|**
Country (1=Kenya: Tanzania=0)	-1.498	0.548	-2.730	0.006
Information + country	-0.098	0.383	-0.250	0.799
Household and plot characteristics				
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
Membership, training and skill acquisition				
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
Access to information				
Had contact with extension services (1=yes: 0=otherwise)	0.103	0.373	0.280	0.781
Institutional services				
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
Household and plot characteristics				
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
Membership, training and skill acquisition				
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
Access to information				
Had information about CA (1=yes: 0=otherwise)	-0.098	0.383	-0.250	0.799
Institutional services				
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
Household and plot characteristics				
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
Membership, training and skill acquisition				
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
Access to information				
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
Institutional services				
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
Household and plot characteristics				
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
Membership, training and skill acquisition				
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
Access to information				
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
Institutional services				
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

CA adoption (treat)	Coef.	Std Err.	Z	P>|z|
Country (1=Kenya: Tanzania=0)	-2.434	0.525	-4.640	0.000
Credit + country	0.838	0.232	3.620	0.000
Household and plot characteristics				
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
Membership, training and skill acquisition				
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
Access to information				
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
Institutional services				
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
Household and plot characteristics				
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
Membership, training and skill acquisition				
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
Access to information				
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
Institutional services				
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

CA adoption (treat)	Coef.	Std Err.	Z	P>|z|
Country (1=Kenya: Tanzania=0)	-3.280	0.692	-4.740	0.000
Agro-dealer + country	1.685	0.377	4.470	0.000
Household and plot characteristics				
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
Membership, training and skill acquisition				
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
Access to information				
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
Institutional services				
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
Household and plot characteristics				
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
Membership, training and skill acquisition				
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
Access to information				
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
Institutional services				
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

ACT African Conservation Tillage Network

"Turning Conservation Agriculture Knowledge into Action"

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

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

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

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

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

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

Village: ………………………………GPS coordinates: Longitude: ………………… Latitude:

…………………….

SECTION A: BASIC INFORMATION

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

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

A3. Level of education of the household head

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

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

A5. People living in homestead

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

M_______ F_______ M_______ F_______ M_______ F_______

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

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

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

A9. Marital status: Married ☐ Never married ☐ Widowed ☐

Separated/Divorced ☐

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

A11. Number of animals in the household

a. Cows........ b. Goats....... c. Sheep......... d. Pigs ......e. Chicken ...... f. Ducks....... g. Others

(specify)

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

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

a. Crop production; b. Livestock production ; c. Business; d. Casual 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 on one hectare		Mostly done by who (Use 1=Male 0=Female)
	CA	Traditional	
Digging planting basins			
Ripping (Hand, Draft animal or Tractor)			
Direct planting in lines			
Sowing in hole with machete / stick			
Jab planting			
Early sowing just after slashing			
Mulching			
Uprooting weeds (not cutting)			
Shallow weeding (scrapping)			
Setting firewalls			
Planting of Cover crops			

Application of manure for fertilizer			
Home preservation of crop residues for mulching			

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

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

SECTION K: ACCESS TO RESOURCES

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

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

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

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

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

SECTION L: SUSTAINABILITY

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

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

offered……………………………………………

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

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

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

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

L5. Have you learnt anything new after the CA project related to the project? ☐ 1=Yes, 2=No If yes, list a maximum of three

....

....
....

....

SECTION M: DIFFUSION OF CA INTERVENTIONS

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

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

6.Start a new business	
7. Other (specify):	

For Non-beneficiaries of the CA project:

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

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

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

(specify)

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

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

M6. If yes, mention how you heard of it

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

………………………………

SECTION J: ACCESS TO CREDIT

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

If no, what is the reason?	lack of awareness high interest rates fear or risk averseness Other (specify)………………………………………….
What was the value of the credit (Value in USD)	....
What was the source of credit?	....
How far is the nearest financial institution?	…………… kilometres
What forms of savings do you practice?	cash saving livestock investments
(tick all appropriate options)	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