

## **Adoption and Impacts of Conservation Agriculture: Quasi Experimental Evidence from E. Africa**

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### **Abstract**

Conservation Agriculture is a recent and evolving concept to land management that seeks to optimise crop yields and farm profits in a manner that balances economic and environmental benefits. The underlying principles include avoiding soil tillage, maintaining soil cover and retaining crop residues, practicing crop rotations and improved fallows, precision placement of appropriate fertilisers, pesticides and herbicides (targeting of inputs), reliance upon integrated pest management (IPM) principles and avoidance of soil compaction, among others.

We use binomial probit analysis and propensity score matching (PSM) methods to investigate the drivers of adoption and assess the impact of conservation agriculture among smallholder farmers in Eastern Uganda and Western Kenya. We use data from 800 small-holder farming households collected in 2010.

The results show that the drivers of adoption are the same in both countries and that although both socioeconomic and biophysical characteristics drive the choice to use conservation agriculture practices, the latter appear to be more important than the former suggesting that increasing land degradation in East Africa will likely trigger increased adoption of conservation agriculture. Farmers whose main livelihood activity is either livestock or non-farm are less likely to adopt conservation agriculture practices whereas the relatively well off farmers are more likely to use conservation agriculture practices. Furthermore, results show that farmers in both countries are more likely to use conservation agriculture practices on degraded or soils prone to degradation. The results do not show any gender based differences.

Using both Kernel and Nearest Neighbour Matching approaches, the results suggest significant impacts on maize yield of over 1000Kgs per ha on plots using conservation agriculture practices, negative impacts on the cost of inorganic fertilisers and result in labour savings of between 11–19 person days per ha per season. We conclude that conservation agriculture has a future in smallholder farming in east Africa with great potential to boost farm productivity and profitability through reduced use of both inorganic fertilisers and family labour inputs.

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Keywords: Adoption, conservation Agriculture, East Africa, Propensity Score Matching

## 1. Introduction

Conservation Agriculture is a recent and evolving concept to land management that seeks to optimize crop yields and farm profits in a manner that balances economic and environmental benefits (Dumanski *et al.* 2006). Conservation Agriculture is a powerful new trend that captures basic ecological principles and cutting edge technologies. The underlying principles of conservation Agriculture include avoiding soil tillage, maintaining soil cover and retaining crop residues, practicing crop rotations and improved fallows, precision placement of appropriate fertilizers, pesticides and herbicides (targeting of inputs), reliance upon integrated pest management (IPM) principles and avoidance of soil compaction, among others.

As a concept of sustainable agricultural production, conservation agriculture aims to conserve, improve, make more efficient use of natural resources as well as contribute to environmental conservation FAO (2008). In order to sustain a permanent profitable system of agriculture, maintenance of soil fertility is paramount. To addresses problems of soil fertility and productivity of smallholder farmers emphasis is sometimes put on options for soil management that show great promise under controlled experimental conditions which gain little foothold in practice (Tittonell *et al.*, 2008).

Conservation Agriculture was first developed for application by large mechanized farmers and its relevance to small holder farmers in the tropics is tenuous, especially with regard to its central pillars of no till, continuous surface cover and crop rotation. Conservation Agriculture does not prohibit the use of particular inputs, as does organic agriculture, rather it stresses that they must be applied at times and rates that cause minimal disturbance to beneficial soil organisms and processes (Sanginga and Woomer, 2009). Conservation Agriculture is practiced on a large scale in South Africa (377,000 ha), and to a lesser extent in other African countries such as Ghana (35,000 ha) with the most common crops being maize, sorghum, wheat and cotton (Derpsch 2008).

Conservation Agriculture has major advantages although there are also potential drawbacks. According to Haggblade and Tembo, 2003, Conservation Agriculture provided 1.1 tons/ha additional maize among Zambian farmers and was more profitable despite higher costs of production. On-station trials in Zimbabwe showed an increase in Maize yield of from 3,200 to 4,000 kg/ha with Conservation Agriculture on well drained soils as a result of reduced water run-off whereas in drier locations Conservation Agriculture increased Maize yields from 2,900 to 3,600 kg/ha (Elwell, 1995).

Compared to other Sub-Saharan Africa (SSA) countries, Uganda appears to have a rather limited experience with conservation Agriculture. Work appears to have started in 1997, with efforts of the National Agricultural Research Systems (NARS) and Africa 2000 Network (an international Non-Governmental Organisation (NGO)) who sought to increase food security through the promotion of integrated nutrient management technologies in the Eastern parts of Uganda. A research project undertaken called the Integrated Soil Productivity Initiative through Research and Education (INSPIRE) project was created comprising the civil society, NGOs, the National Agricultural Research System (NARS), the International agricultural research centres and government departments. The eastern region district of Tororo was targeted owing to its dense population of over 280 persons per square kilometer and the poor endowment of natural resources characterized by sandy loam soils that are largely acidic and potassium (K) deficient, and its annual crop dominated cropping system. Soil erodibility and erosivity is moderate (Wortmann and Eledu, 1999 as cited by Miiro et. al, 2002). Furthermore, about 82% of the land in Tororo district land is farmed making this area a high incidence poverty area (World Bank 1993). In Kenya, the sustainable Agriculture Centre for Research and Development in Africa (SACRED) promotes projects that help farmers to sustainably improve soil fertility, access superior seed and market their produce profitably. Meanwhile, Manor House Agricultural Centre (MHAC) currently promotes Bi-Intensive Agriculture (BIA) a low cost sustainable agricultural technology suited to small scale farmers, composting to improve soil fertility, deep soil preparation to enhance growth, mulching to conserve moisture, close spacing to improve productivity and biological pest control to manage plant diseases (Jeavons, 2002).

## **2. Objective and Research questions**

The objective of this research is to investigate the drivers of adoption and impact of conservation agriculture practices among smallholder farmers in eastern Uganda and western Kenya.

### **Research questions**

- (i) What drives the choice to use or not use conservation agriculture practices among small holder farmers in Eastern Uganda and Western Kenya?
- (ii) What is the relative importance of socioeconomic and biophysical drivers of adoption of conservation agriculture practices?
- (iii) Given the differences in the policy and socioeconomic context, is there a difference in the drivers of conservation agriculture between Kenya and Uganda?
- (iv) Are there any gender or other farmer based differences in the drivers of adaptation to conservation agriculture?
- (v) What is the impact of Conservation Agriculture on selected livelihood indicators?

### 3. Methodology

#### 3.1. Models

Binomial probit regression model is used to investigate the drivers of conservation agriculture whereas the Propensity Score Matching (PSM) method is used to assess the impact of conservation agriculture on selected livelihood indicators. Hence binomial probit regression is used to address research questions (i), (ii), (iii) and (iv) whereas the Propensity Score Matching (PSM) method is used to answer research question number (v). The two models are mathematically specified and described in what follows.

##### 3.1.1. The Probit Model

Suppose response variable  $Y$  is *binary* meaning that it can have only two possible outcomes which we will denote as 1 and 0. We can define  $\mathbf{X}$  as a vector of regressors which are assumed to influence the outcome  $Y$ . Specifically we assume that the model takes the following mathematical form (Greene,2003):

$$\Pr(Y=1/\mathbf{X}) = \Phi(\mathbf{X}'\boldsymbol{\beta}),$$

Where  $\Pr$  denotes probability, and  $\Phi$  is the Cumulative Distribution Function (CDF) of the standard normal distribution. The parameters  $\boldsymbol{\beta}$  are typically estimated by maximum likelihood. It is also possible to motivate the probit model as a latent variable model. Suppose there exists an auxiliary random variable

$$Y^* = \mathbf{x}'\boldsymbol{\beta} + \varepsilon,$$

Where  $\varepsilon \sim N(0,1)$ . Then  $Y$  can be viewed as an indicator for whether this latent variable is positive:

$$Y = 1_{\{Y^* > 0\}} = \begin{cases} 1 & \text{if } Y^* > 0 \text{ i.e. } -\varepsilon < \mathbf{X}'\boldsymbol{\beta} \\ 0 & \text{, otherwise} \end{cases}$$

The empirical probit model used to analyze the drivers of adoption of conservation agriculture practices in the East Africa region is specified as follows:

$$Y = \alpha + \mathbf{b}_i \mathbf{X}_j + e_i$$

Where:  $Y$  is a binary response variable as to whether the particular household practices at least one of three conservation agriculture practices ( $Y=1$ ) or none at all ( $Y=0$ ).  $\mathbf{X}$  is a vector of regressors affecting the choice of the response variable including socioeconomic factors and plot level characteristics or biophysical and edaphic factors that are presented in Table 3.

##### 3.1.2. Impact Assessment

Impact assessment relies on a variety of methods that fall under the following four categories. Econometric approaches which are aimed at estimating the marginal productivity coefficients; mathematical programming methods which are aimed at identifying one or more optimal options from a set of options; the economic surplus methods, aimed at measuring the aggregate social benefits of a particular research project; and indicator approaches. These methods tend to ignore economic valuation entirely and simply use adoption rates, yield levels, quantities produced and other indicators of the perceived success of a particular project or intervention. The indicator approach usually

becomes necessary when other data needed for an economic assessment are missing. In the present analysis we use the Propensity Score Matching (PSM) method which is one of the recent impact assessment approaches. PSM is briefly described in what follows.

### **3.1.3. Propensity Score Matching (PSM)**

Propensity Score Matching (PSM) has become a popular approach to estimating causal treatment effects (Caliendo and Kopeinig, 2005). PSM applies in all situations where one has a treatment, a group of treated individuals and a group of untreated individual. As observed by Caliendo and Kopeinig (2005) every microeconomic evaluation study has to overcome the fundamental evaluation problem and address the possible occurrence of selection bias. The problem arises because we would like to know the difference between participant's outcome with and without treatment but we cannot observe both outcomes for the same individual at the same time. Caliendo and Kopeinig further advise against taking the mean outcome of non – participants as an approximation since participants and non-participants usually differ even in the absence of the treatment. This is the problem known as "selection bias" and the matching approach is one possible solution to the selection problem. It originated from the statistics literature and shows a close link to the experimental context. Its basic idea is to find, in a large group of non – participants, those individuals who are similar to the participants in all relevant pre – treatment characteristics  $X$ . That having been achieved, the difference in outcomes of this well selected and thus adequate control group and of participants can be attributed to the programme or intervention. Caliendo and Kopeinig (2005) note that conditioning on all relevant covariates is limited in case of a high dimensional vector  $X$  ("curse of dimensionality").

Rosenbaum and Rubin (1983) suggest the use of so – called balancing scores  $b(X)$  i.e. functions of the relevant observed covariate  $X$  such that the conditional distribution of  $X$  given  $b(x)$  is independent of assignment into treatment. The propensity score (the probability of participating in a program given observed characteristics  $x$ ) is one possible balancing score. Matching procedures based on this balancing score are known as propensity score matching (PSM). Available matching algorithms include the Nearest Neighbor (NN); Caliper and Radius; Stratification and Interval; Kernel and local Linear; and Weighting. The PSM is widely used (see e.g. Dehejia and Wahba (1999) or Heckman, Ichimura and Todd (1997), Hitt and Frei (2002) or Kassie et al (2010).

In the present study we assessed impacts of conservation agriculture on maize yield, fertilizer costs and intensity of family labour use (family labor use per ha) using Propensity Score Matching with both Kernel matching and Nearest Neighbor matching approaches. We used different matching estimators to demonstrate robustness of the results.

### **3.2 Data, data sources and analysis**

Baseline field interviews were conducted in all four project districts during the period July and August 2010. 800 household interviews were conducted (200 per district). The survey covered 4 districts two each in Uganda and Kenya. The two districts in Uganda were Tororo and Kapchorwa whereas the two districts in Kenya were Bungoma and Trans-Nzoia. Tororo and Bungoma are low land districts whereas Kapchorwa and Trans-Nzoia are highland district areas. Half of the selected respondents were women. Sample selection followed the following sampling procedure. Two sub-counties were randomly selected from each of the 4 districts making a total of 8 (2x4) sub-counties. In each sub-county two parishes were randomly selected making a total of 16 (8x2) parishes. Sampling frames were compiled for each of the 16 parishes from which a sample of 50 households was randomly drawn using systematic sampling from a random start. Out of the selected 50 households, female headed households were removed and put on the female interview list. The number of additional female interviewees needed to make 25 female-headed households were then calculated. That number was then randomly selected from the original sampling frame so that two sub-lists of 25 respondents – one for female headed and the other for male headed were created for each of the parishes. Data analysis was undertaken using both the Statistical Package for Social Scientists (SPSS) and STATA Econometrics program.

## **4. Results and Discussion**

This section presents and discusses selected descriptive statistics followed by the binomial probit analysis results and finally impact assessment results based on the PSM

### **4.1. Descriptive Results**

#### **Socio economic characteristics of adopter versus non adopter households**

This section examines selected characteristics of adopters compared to non adopters of conservation agriculture practices, regardless of district of location. Differences in various characteristics for adopters versus non adopters were tested using Pearson's chi squared test statistics in cross tabs for categorical variables using SPSS (Howell, 2010; Laird Statistics, 2013) and using t-test for continuous variables (Wolfe and Hollander, 1973). Both chi-square and t-test were conducted at 5% significance level. For ease of exposition, the socioeconomic characteristics examined are grouped into three categories namely household demographic factors, land ownership as a proxy for resource endowment, and institutional factors. These are discussed in what follows.

#### **Household demographic characteristics**

Descriptive results show that there is no significant difference between adopters and non-adopters of conservation agriculture in terms of key household demographic factors such as education, household size, number of economically active household members and age of head of household as presented in Table 1. These results suggest that household demographic characteristics largely have no direct bearing on the household choice of whether or not to use conservation agriculture practices.

**Table 1: Household demographic characteristics of adopters and non-adopters of Conservation Agriculture.**

Variable	Description	Non – Adopters (N=149)	Adopters (N=118)	Probability (significance)
Education	Primary	75	65	0.258 <sup>a</sup>
	Post primary	74	53	
Household size	Number of people in HH	7.27	7.58	0.44 <sup>b</sup>
Economically active household members	Mean number active HH member	3.38	3.076	0.320 <sup>b</sup>
Age of head of household	Average Age in years	45.8	46.2	0.816 <sup>b</sup>

<sup>a</sup>Calculated from a Pearson chi-square statistics assuming 1 degree of freedom. If probability is less than 0.05 (5% level of significance) then the null hypothesis of ‘no significant difference between adopters and non – adopters’ is rejected (Howell, 2010).

<sup>b</sup>Calculated from t-test, if probability is less than 0.05(5% level of significance) then the null hypothesis of ‘no significant difference between adopters and non adopters’ is rejected

#### **Land ownership (size of land owned)**

In terms of land ownership, adopters of conservation agriculture practices own more land (4.5 acres) than non adopters (3.7 acres). The difference between the two is significant as shown in Table 2. Access to land was hypothesized to positively influence a household's likelihood of adopting conservation agriculture practices because large farm size can be a good proxy indicator of greater wealth, more capita and higher risk bearing ability which make investment in conservation agriculture more feasible (Norris and Batie, 1987).

**Table 2. Land ownership between adopters and non-adopters of conservation Agriculture.**

Statistics	Non Adopters	Adopters
Mean (acres)	3.67	4.50
Variance	17.30	38.68
Observations	140	118
Hypothesized Mean Difference		0
Df		198
T Sta		1.23a
P(T<=t) two-tail		0.22
T Critical two-tail		1.97

a Calculated from t-test. If probability is less than 0.05 (5% level of significant) then the null hypothesis of ‘no significant difference between adopters and non – adopters’ is rejected

### **Institutional factors**

Institutional factors, such as household membership in farmer organisations, access to agricultural credit, and access to public extension services and several others may influence the households likelihood to adopt conservation agriculture practices. Farmers in the study area identified extension service providers, fellow farmers, and religious and community leaders as important sources of information on new farming practices and technologies. Makoha et al. (1999) showed that, for farmers in western Kenya, contact with government extension services, and participation in agricultural seminars and workshop, had a statistically significant impact on adoption behavior. The results of this study show that a small proportion of adopters of conservation agriculture were visited by government extension service providers compared to non-adopters.

## **4.2. Econometric results**

### **4.2.1. Drivers of adoption of conservation Agriculture**

The probit analysis results to analyze those factors that drive the choice to use conservation agriculture practices are presented in Table 3. Interpretations are based on marginal effects. The results show that both socio economic and biophysical characteristics drive adoption of conservation agriculture practices in both countries. Our results agree with Demeke and Abera (2003) who found that farm size and farmers' perceptions of benefits positively influenced the decision to adopt soil conservation practices in Northwest Ethiopia. Berhanu and Swinton (2003) also showed that land tenure security significantly influenced adoption of natural resource conservation practices in Northern Ethiopia. However, in the present study, adoption appears to be more driven by biophysical and edaphic conditions (or land conditions or soil conditions) than by socio economic and socio demographic conditions of the household. This seems to hold for both Uganda and Kenya suggesting that programs aimed at increasing the farmers' awareness of their land and soil characteristics may constitute a more effective approach to promoting the use of conservation agriculture practices in the east Africa region. This finding further suggests that increasing land degradation in East Africa will likely trigger more adoption of conservation agriculture, which indicates widened future prospects of use of conservation agriculture practices.

Furthermore, the drivers of adoption of conservation agriculture appear to be the same in both Uganda and Kenya. From our sample study sites, we do not see any differences in the drivers of adoption between the two countries. Therefore development strategies to promote conservation agriculture in both countries could be shared and replicated and lessons from each country will be complimentary and synergistic.

Furthermore, farmers whose main livelihood activity is either livestock or non-farm are less likely to adopt conservation practices compared to those whose main activity is crop production. Our results appear contrary to those from studies by Demeke and Abera (2003) and Mathege and Tschirley (2007). The study by Demeke and Abera (2003) established that distance from the homestead to the plot, availability of off-farm employment and tenure insecurity negatively influenced the decision to adopt soil

conservation practices. Mathege and Tschirley (2007) also reason that non-farm occupation offers households an opportunity to earn off-farm income which can mitigate the risk of experimenting with new farm technology, in essence implying that access to off-farm income positively influences adoption. Also, controlling for other factors, we do not find a gender effect on the adoption of conservation agriculture, therefore both male and female headed households are equally likely to adopt conservation agriculture practices. This is despite the fact that previous studies in Africa have shown women to be less privileged with inadequate access and control of productive resources including land, cash, labour and information (Quisumbing et al., 1995; Kaliba et al., 2000 and Nabikolo et al., 2012). This result may imply that we may not need gender specific targeting to promote wider adoption of these practices.

Using number of rooms as a proxy for poverty, our results show that it's the relatively well off farmers in both countries that are more likely to use conservation agriculture practices. Our results do not fully support the hypothesis that conservation agriculture is pro-poor. It is likely that the poor farmers have some other constraints not captured by our analysis that could be limiting their participation in conservation agriculture key among them being risk aversion. This finding needs to be further tested using better quantitative poverty indicators such as that based on consumption expenditure data rather than a qualitative indicator we have used here.

In terms of biophysical factors, farmers appear to be using conservation agriculture practices on soils that appear somewhat degraded or prone to soil degradation. This result is contrary to the findings by Calatrava et al., (2007) who found that investment costs of adopting conservation agriculture practices are generally lower in areas with smaller risk of soil erosion. Our results suggest that farmers are more likely to use conservation agriculture practices on lands that are steep or gently sloping than on flat lands. However, our slope results are consistent with Calatrava et al., (2007) who observed that investment costs of adopting conservation agriculture practices are generally lower in areas of gentler slopes. Smallholder farmers in both countries are unlikely to use conservation agriculture practices on lands that are not severely eroded. These results indicate that farmers are responding to soil fertility issues using conservation agriculture on farm land locations that are prone to erosion.

**Table 3. Maximum Likelihood Binomial Probit regression explaining use or non-use of conservation practices (Marginal effects). Dependent Variable:** Use of any one or combination of the three conservation agriculture practices = 1; otherwise = 0.

<b>Explanatory Variables:</b>	<b>All</b>	<b>Uganda</b>	<b>Kenya</b>
<b>Household Characteristics ( Socio economic factors)</b>			
Main activity Livestock (omit=Crop production)	-1.002**	(omitted)	-0.815*
Main activity Non-farm	-0.358*	0.006	-0.288
Primary level education (Educpri) (omit=No educ)	0.418*	0.530*	0.547**
Secondary level education (Educ Sec)	0.37	0.528	0.514*
Tertiary Level Education (Educ Tert)	0.526	0.773	0.608
Female headed household	-0.157	0.165	-0.133
Age of household head (Agehhd) in years	0.005	0.004	0.007
Household size (Hhdsiz) number of persons	0.044	0.04	0.046
Number of rooms in the house (Proxy for poverty)	0.209***	0.291**	0.242***
Number of males above 18 yrs.	-0.234***	-0.295**	-0.191**
Number of females above 18	-0.005	-0.053	-0.012
Distance of plot from homestead	0.017	0.167**	0.01
<b>Plot Characteristics (Biophysical factors):</b>			
slope gentle (omit=Flat)	0.447***	0.714***	0.365**
slope steep	0.780***	0.823	0.579*
soil sandy loam	0.425	0.844*	0.25
soil loam	1.044***	1.787***	0.661**
soil clay	1.078**	1.626***	1.022**
soil clay loam	-0.08	0.013	-0.089
Soil erosion perceived as not problem	0.089	-0.298	0.041
Soil erosion perceived as a problem	0.565***	0.695*	0.261
_cons	-1.507***	-2.362***	-1.673***
N	406	207	303

*Standard errors are corrected for heteroscedasticity using Huber-white sandwich estimator. \*\*\* p<0.01, \*\* p<0.05, \*p<0.1*

#### **4.2.2. Impact of Conservation Agriculture**

As earlier noted, we assessed the impact of conservation agriculture practices on the welfare of households based on selected indicators using the Propensity Score Matching (PSM) method with both Kernel Matching and Nearest Neighbour Matching approaches. We used different matching estimators to demonstrate the robustness of the results. Owing to data limitations we chose maize yield, fertilizer cost in maize production and the extent of use of family labor in maize production as indicators. We based the analysis on maize because it is a major crop in all the four locations in both countries

We used pooled data analysis to increase the degrees of freedom and improve on identification. The results presented in Table 4. robustly show significant impacts on maize yield of over 1000Kgs per ha on plots using conservation agriculture practices compared to those plots without conservation agriculture. According to the Food and Agriculture Organisation (FAO, 2008), the adoption of conservation agriculture brings not only direct financial rewards to the farmers but also broader community and environmental benefits. Our results are also consistent with observations from a Zimbabwe study by Mazvimavi and Twomlow (2009). This study noted that conservation agriculture had been very popular in Zimbabwe because smallholder farmers who adopted it had generally experienced increased crop production and improved food security. Yield gains associated with conservation agriculture ranging between 10% and more than 100% were also reported. Conservation agriculture has also been shown to tremendously improve food productivity and the incomes of poor farmers in Zambia (Baudron et al., (2007).

**Table 4. Impacts of conservation agriculture on Maize Yields fertilizer cost and family labor (pooled data for Uganda and Kenya).**

	<b>PSM –Kernal Matching (Epanchinov)</b>	<b>PSM – Kernal Matching (Normal)</b>	<b>PSM –Nearest Neighbour Matching (5 neighbours)</b>	<b>PSM –Nearest Neighbour Matching (10 neighbours)</b>
<b>Maize Yields</b>	<b>1310.1***</b> (265.5)	<b>1310.1***</b> (238.8)	<b>1139.9***</b> (236.2)	<b>1146.8***</b> (225.6)
<b>Fertiliser Cost (US\$)</b>	<b>-10.5</b> (12.3)	<b>-10.5</b> (10.1)	<b>-16.9***</b> (6.13)	<b>-15.4***</b> (5.53)
<b>Family labor/ha</b>	<b>-19.6**</b> (9.2)	<b>-19.6</b> (18.8)	<b>-12.1***</b> (5.19)	<b>-11.2**</b> (5.3)

*Figures in parentheses are standard errors: \*\*\* p<0.01, \*\* p<0.05*

Advocates of conservation agriculture use have generally recommended and promoted use of some form of inorganic fertilizer as a means of boosting soil fertility alongside any conservation agriculture practices Mazvimavi et al., (2010). Other researchers working in Sub-Saharan Africa (SSA) have also advocated combinations of mineral and organic nutrient sources because of the immobilization effects of organic sources alone and because of short supplies of organic sources (Okalebo et al., 2006; Rowe et al., 2006 and Vanlauwe and Giller, 2006). The results in Table 4 show that use of conservation agriculture practices has a negative impact on the cost of inorganic fertilizers. More significant reductions in fertilizer costs are identified with Nearest Neighbor Matching. This result suggests that conservation agriculture practices are alleviating the cost of inorganic fertilizer and hence use among smallholder farmers in East Africa. This is particularly important for Uganda where inorganic fertilizers are both costly and unavailable with an application rate of under 1kg per ha compared to 35 kg/ha for Kenya and 22 kg/ha for Malawi and 13 kg/ha for Tanzania (Wallace and Knausenberger, 1997).

With regard to use of family labor, the results show that conservation agriculture practices had a **significant negative impact** on family labor days used per ha, resulting in a saving of between 11-19 family labor days per ha compared to those households not using conservation agriculture practices in maize production. This evidence suggests that conservation agriculture technology may be an effective way of easing family labor constraints among maize producing farmers. These labor benefits of conservation agriculture are also noted by Sanginga and Woomer (2009) who observe that farmers receive greater yield stability, higher economic returns to inputs, reduced demand for fuel and labor and greater retention of water and nutrients in the soil. This study further notes that less labor is required for land preparation and other field operations.

## **5. Conclusion**

Development interventions focused at improving the wealth status of households (poverty reduction) stand a good chance of fostering adoption of conservation agriculture compared focusing on the institutional elements and altering household demographic profiles.

Increasing farmers' awareness of their land and soil related factors provides an attractive entry point to promoting the use of conservation agriculture practices and the experiences gained can be shared between Uganda and across the gender divide.

Conservation agriculture has greater potential to increase the welfare of smallholder farmers through higher productivity and a reduction in the cost of production provided commodity prices stay the same or show an improvement.

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