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Abstract

In 2012, the 'Empowerment of Women – Benefit (for) All' (EWA) project started in two districts in Eastern Uganda. The aim of the project is to empower small scale farmers by gaining knowledge and experience in conservation agriculture. NGOs Women in Europe for a Common Future (WECF) and AT Uganda Ltd. established 100 demonstration fields of maize intercropped with beans. Within a demonstration field, two agricultural methods are used: one part of the field conservation agriculture (CA), and one part traditional agriculture (TA). By pulling together group discussions, individual surveys and yield data of the demo fields in 2014, this paper presents an evaluation of the EWA project. Evidence shows that the use of CA leads to higher yield, but also but also to a higher demand for labour. The attribution of these effects can't fully be explained based on the data available. The majority of the interviewed respondents adopted one or more principle(s) of CA on their own land.

Keywords: Conservation agriculture, project evaluation, WECF, AT Uganda Ltd., Uganda

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1. Introduction

In the beginning of the 21tst century, the agricultural sector in Uganda faces a series of challenges. Uganda ranks 9th in the list of the world's fasting growing countries, annually 3,24% which increases the pressure on land (CIA 2015). Moreover, the need to meet the demand for food, feed and fibre depends upon 73% on the production from small scale farmers (Nagayets 2005). Simultaneously, the agricultural sector has to deal with the consequences of climate change leading to longer dry periods, and erratic rainfall (Worldbank 2015). To deal with these challenges and ensure food security, an increase in agricultural productivity (in terms of yield) is needed. However generally, an increase in productivity has a negative impact on the environment. The quality of soil, water, biodiversity and ecosystems decreases as agricultural production intensifies (Friedrich, Derpsch et al. 2012).

According to Food and Agriculture Organization of the United Nations (FAO), conservation agriculture (CA) is believed to take on the challenges described above, while simultaneously account for the negative effects on the environment (FAO 2014) Moreover, conservation agricultural has the potential to increase income and therefore the livelihoods of farmers. This offers an interesting prospect for Uganda, where around 60% of the population depends on agriculture as a source of income (FAO 2015).

In 2012, the 'Empowerment of Women – Benefit (for) All' (EWA) project, put this statement to the test by establishing 100 demonstration fields of conservation agriculture in two districts in Eastern Uganda. The demonstration fields with maize and beans are separated in two parts: one part for conservation agriculture, and one part for traditional agriculture (TA). Each demo field is cultivated by one local farmer group, so overall there are 100 groups. In total, around 2000 women and men are involved in the project. During the three year that the EWA project is operational, the number of demonstration fields has increased, demonstrating the use of conservation agriculture with various types of crops.
The three-year-project is organised by Women in Europe for a Common Future (WECF) in cooperation with local NGO AT Uganda Ltd. and funded by the Dutch Ministry of Foreign Affairs. The aim of the EWA project is to empower small scale farmers by gaining knowledge and experience in conservation agriculture while simultaneously identifying the effect of conservation agricultural on yield, income and environment. Moreover, by selecting farmer groups where the majority of the group is female, the EWA project aims to improve the position of female farmers.

This paper presents an analysis of the effectiveness of conservation agriculture and the EWA project, now currently in its third and final year. Prior to data collection, pre-analysis plan (1) has been written. Pre-analysis plan (2), written after data collection but before the analysis, presents the set-up of the research design of the evaluation. Both plans can be found at http://www.wageningenur.nl/en/Expertise-Services/Chair-groups/Social-Sciences/Development-Economics-Group/Education/Student-reports-and-data.htm

The evaluation of the EWA project can be divided into two sections:

1) Comparative analysis of CA
   The analysis of conservation agriculture focuses on its performance. The analysis starts with a comparative analysis of the cultivation and inputs used on the two parts of the demonstration fields. Moreover, a model is introduced to find the true effect of conservation agriculture on yield. The section concludes with a profitability analysis of conservation agriculture compared to traditional agriculture.
2) Analysis of adoption and replication CA
   This second part of the evaluation is an analysis of the use of CA outside the borders of the demonstration fields. The level of adoption represents the number of project participants that has

adopted one or more principle(s) of conservation agriculture on their own land. The level of replication depicts the number of non-project participants, so people who are not part of the EWA project, who replicated one or more principles of CA on their own land. A model will be estimated to analyse the intensity of adoption and how different factors influence adoption.

An analysis of replication among non-project participants will show the potential of conservation agriculture to be carried outside the project. Also, an overview is provided of what, according to the project participants, are the benefits and challenges of CA.

The evaluation will enhance our understanding of conservation agriculture and its potential for small scale farmers in (Eastern) Uganda.

The evaluation is based on both qualitative and quantitative data. The first part, the analysis of CA, is based upon the yield of maize and beans in 2014. From 184 demonstration fields, the yield of maize has been collected. The yield of beans, functioning as an intercrop for maize, was gathered from 68 fields. The difference in available data is because host farmers choose not to plant it, or because the crop failed due to severe rain and wind. Because of this difference in data availability, the emphasis in the yield analysis will be on maize. All yield data is collected by AT Uganda Ltd. From the 100 farmer groups, 74 groups participated in a group discussion where social-demographic information has been collected, next to local market prices, the benefits and disadvantages of conservation agriculture and the level of adoption within the group and replication outside the project. Two types of individual surveys were done. The first, survey A, included 297 people, who answered questions about socio-demographic characteristics, characteristics of their demonstration field and empowerment related questions. The second survey, survey B, included 139 host farmers, questioning, next to socio-demographic characteristics, the characteristics of their demonstration field, as well as its cultivation.

This paper consists of five chapters. Section 2 provides a theoretical background of conservation agriculture and the set-up of the EWA project. Hereafter, the research design, data, models and descriptive statistics are presented in Section 3. The results of the models are discussed in Section 4. Section 5 entails the conclusion of the evaluation. Tables are included in the Appendix.

2. Theoretical background

2.1 Conservation agriculture

Starting in the 1930s, the concept of conservation agriculture sprouted when so-called dustbowls limited agricultural production in the mid-west of the United States. Over the years, ideas similar to conservation agriculture occurred, but only in the 1990s the spread of conservation agriculture started to become significant. Countries as Brazil, Argentina and Paraguay functioned as trendsetters, and soon the practises of conservation agriculture were adopted in a few African and Asian countries (Friedrich, Derpsch et al. 2012).

But what exactly is conservation agriculture? According to the FAO, conservation agriculture is 'an approach to managing agro-ecosystems for improved and sustained productivity, increased profits and food security while preserving and enhancing the resource base and the environment' (FAO 2014).
The definition revolves around three basic principles, described by (Friedrich, Derpsch et al. 2012).

(1) Practicing minimum soil disturbance
Minimum soil disturbance from cultivation, harvest and farm traffic through minimum or zero tillage, by direct sowing and direct placing planting material.

(2) Protecting soil with permanent or semi-permanent soil cover
The soil covered by crop residues, mulch or cover crops.

(3) Practice of crop rotation with more than two crop species

The three principles are explained and illustrated in the following section. Also, the implementation of conservation agriculture in the EWA project is discussed.

Agriculture as we know it during the past century includes tillage in the form of physically manipulating the soil to create a weed free and smooth surface where seeds can easily be planted in, such as ploughing Baker and Saxton (2007). However, as research of the (FAO 2014) has shown, in the long run, tillage can destroy the soil structure and decrease soil fertility. To increase the quality of the soil, or to keep it constant, conservation agriculture embraces the idea of minimum soil disturbance. In the EWA project, the definition of Baker and Saxton (2007) is used: 'no prior disturbance or manipulation of the soil has occurred other than minimal disturbance operations such as shallow weed control, fertilization and loosening of subsurface compacted layers'. Moreover, minimum soil disturbance has the potential to reduces costs associated with ploughing, such as the use of tractors or animals (Hobbs 2007).

Together with the concept of minimum soil disturbance, the soil is protected with a (semi-)permanent cover. This cover can consist of residues of the crops that are grown, but also of mulch or cover crops. The cover acts a shield for rain, wind and water, which simultaneously reduces soil erosion. Moreover, it improves the structure and water holding capacity (Lu, Watkins et al. 2000) In addition, ground cover increases biological diversity. Jaipal, Singh et al. (2002) argue that there are more insects present which contributes to control pests. However, covering the soil can also lead to too much biodiversity; attracting animals such as termites or rats who eat the seedlings or crops (FAO 2014). Research of Teasdale (1996) shows the pros and cons of each type of cover. Crop residues of crops grown last season help to suppress weeds in the beginning of the next season, but can't be used all year long due to decomposing. Though, the decomposition also adds nutrients to the soil. Cover crops can protect the soil all year round, but can be competitive to the cultivation of the main crops. Moreover, farmers are not keen to invest in a cover crop that doesn't benefit financially.

The third principle of conservation agriculture, crop rotation, contributes to soil fertility and soil structure because when crops are changed every season or year, the soil is used in different ways. Some crops grow deeper than others, or crops extract different nutrients from the soil (Bullock 1992). Another important benefit of rotation is that when the same type of crop is planted over and over again, it becomes very vulnerable to pests, weeds and diseases. For example, when a single crop is grown, it allows specific weed species to become dominant which makes it hard to control (Chauhan, Singh et al. 2012). Other benefits of crop rotation are that farmers are less vulnerable to market price fluctuations of crops and it results in a varied diet (FAO 2014). In the EWA project, intercropping is carried out by combining maize and beans.

Conservation agriculture requires adapted pest-, weed- and disease management. Especially in the first years after the transition to conservation agriculture, extra measures are needed to control the weeds because of minimum tillage (Wall 2007). This is compensated by soil cover which should reduce the growth of weeds. However, according to Giller, Witter et al. (2009), there is not a lot of evidence to back this claim. The demonstration fields of the EWA project are managed with the use of organic pesticides in which the farmers are trained to use by themselves.

Just as conventional agriculture, conservation agriculture uses fertilizers to increase production. However, the difference is the amount of fertilizer that is needed. A study of Hobbs and Gupta (2004) shows that fertilizer use with conservation agriculture is more efficient because the fertilizer can be placed together with the seed. This is more efficient than the traditional method, where it is common to broadcast fertilizer along the entire field. This means that with conservation agriculture, less fertilizer is needed to achieve the same nourishing effect.

Another input that potentially could be reduced is labour. Because there is no need for ploughing or other types of tillage, the amount of labour during this phase is diminished. However, more labour is needed for weeding. A study of Siziba (2008) clearly shows a shift in labour use profiles. This shift is important because the labour shifts from specific male related tasks such as ploughing to weeding which is mainly done by women (Giller, Witter et al. 2009). This increases the burden on women, interfering with the aim of the EWA project to contribute to women empowerment. Another challenge of conservation agriculture is covering the soil. If there is no suitable cover crops, mulch is applied. Collecting and spreading the mulch can be time consuming (WECF 2014). Moreover, there is high competition in the use of mulching materials. People use it as feed for life stock, as firewood or as building material (Giller, Witter et al. 2009).

So does conservation agriculture fulfil its promise of a positive effect on yield and the environment? That is hard to say. A solid conclusion of the worldwide functioning and impact of conservation agriculture is difficult to make. Namely, the term 'conservation agriculture' is used as an umbrella, where different methods are covered within one definition. For example, the analysis of Knowler and Bradshaw (2007) shows that methods labelled as conservation agriculture differ in type of tillage (minimum or zero), type of inputs (organic or synthetic), type of cover (crop or mulch), the amount of cover and the type of crop. For this study, the worldwide functioning of conservation agriculture is not relevant, since the focus is not on the universal impact, but on its local functioning in the Kween and Kapchorwa districts in Eastern Uganda, where the EWA project is implemented.

2.2 Conservation agriculture in Sub-Saharan Africa

Only 0.78% of land (981 640 ha) under conservation agriculture lie in Sub-Saharan Africa (Friedrich et al., 2012). However, the attention and adoption of conservation agriculture is increasing, especially in Eastern and Southern Africa. Promotion programmes are set up by the NEPAD (New Partnership for Africa's Development) and recently by AGRA (Alliance for a Green Revolution in Africa). According to (Kassam, Friedrich et al. 2009), in Africa, where 'the majority of the farmers are resource poor and rely on less than 1 ha, (...) conservation agriculture systems are relevant for addressing old as well as new challenges of climate change, high energy costs, environmental degradation and labour shortages'.

2.3 EWA Project

The EWA project is implemented in two districts in Eastern Uganda, on the slopes of Mount Elgon (see Figure 1). The three-year-project is organised by Women in Europe for a Common Future (WECF) in cooperation with local NGO AT Uganda Ltd and implemented under the umbrella of the FLOW Programme of the Dutch Ministry of Foreign Affairs. WECF is an international network of over 100 environmental and health organisations worldwide. AT Uganda Ltd., is involved in facilitating access to agricultural extension support (value chain, technology, research) to some of the poorest and most remote areas in the country (ATU 2014).

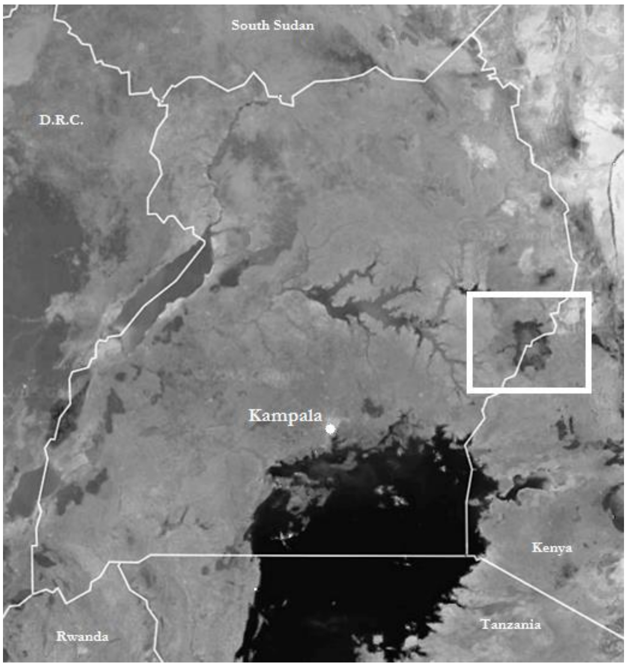

Figure 1: Mount Elgon region, Eastern Uganda[1]

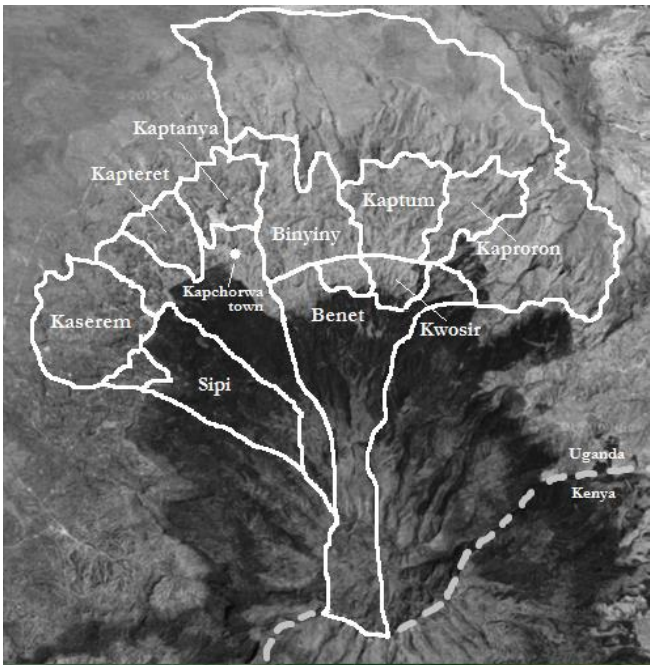

Figure 2: Project area – Kween and Kapchorwa district[3]

2.3.1 Selection project area

AT Uganda Ltd. has been operating in this area in the decade implementing a variety of agricultural projects. The districts of Kween and Kapchorwa struggle with high population growth, deforestation and a mountainous landscape which has led to severe erosion and land degradation. This has led to a decreased soil productivity (WECF 2014). By introducing conservation agriculture, the EWA project tries to reduce erosion, improve soil quality and therefore increase agricultural production.

The subcounties within Kapchorwa district that participate in the project are: Kaserem, Kabeywa, Sipi, Kapteret and Kaptanya. In Kween district, these are Binyiny, Kaproron, Kaptum and Kwosir (see Figure 2). These subcounties are selected because of the presence of local organizations and farmer groups. More about this in subsection 2.3.2 'Selection project participants'. Kapchorwa district is located between latitudes and longitudes 1°34'N, 34°40'E, while Kween district is situated between latitudes and longitudes 1°45'N, 34°58'E. Kapchorwa and Kween districts lie between 1800 – 2200 metres above sea level. The Mount Elgon region is characterised with a rainy season from April to November, and a dry period from December till February. The average temperature is 20.9°C and the average annual amount of rainfall is 1112.5 mm (Weatherbase 2015).

[2, 3] Source: Google Maps

2.3.2 Selection farmer groups

In combination with local organizations within the districts, AT Uganda Ltd. identified eligible farmer groups. This means that the farmer groups already existed prior to the EWA project. During data collection, no information has been gathered about the origin of the groups, or the reasons why people joined a group. Famers groups became more eligible if the majority of the members is female. In every sub county, ten groups have been selected. To participate in the project, farmers were obliged to participate in trainings and to help the host famer (the person who volunteers a piece of land to be used as a demonstration field) to cultivate the demonstration field. No other selection criteria were set.

The farmer groups are responsible to cultivate the demonstration fields, to manage decision making within the group and allocate their time. The majority of the groups also participate in group saving schemes. The composition of the groups varies from women only, to mixed groups and groups with youth members. In every group there is at least one host farmer who volunteers a small part of his or her land to be used as a demonstration field.

In exchange for participation, the farmer groups received trainings from the EWA project. These trainings covered conservation agriculture and its practices, such as crop rotation, making of compost and the usage of organic pesticides for weed-, pest-, and disease control. But also trainings in marketing, farming as a business (FAAB) and gender aspects were given. Inputs to use on the demonstration fields were provided: seeds, fertilizer and top dressing. The farmer groups provided the remaining inputs such as mulch, pesticides, tools, machinery and labour. In theory, the yield of the demo field belongs to the host farmer, but some groups decided themselves to divide it among all group members.

2.3.3 Supervision farmer groups

These trainings described above were given by Community Based Facilitators (CBF) who themselves are trained and paid by AT Uganda Ltd. In every sub county there are two CBFs who both supervise five groups. However, currently there are 16 CBFs employed. In Kaptum, Kabeywa, Sipi and Benet, the CBF assists all ten groups (instead of five). A CBF functions as an intermediary between AT Uganda Ltd. and the farmer groups. They join meetings of the groups, provide trainings, organise discussions, and report to AT Uganda about the performance of the groups. In some cases, the CBF is member of one or more farmer groups as well. To help the CBFs to fulfil this task, 19 Community Based Monitors (CBM) were employed to ensure that planned activities of the groups are done and to obtain feedback of the farmers. However, due to low quality of work and a tight budget, all CBMs were released at the end of 2014. This means that during the final year of the project, the CBFs work without the assistance of the CBMs.

2.3.4 Demonstration fields

All demonstration fields have the same lay-out as presented in Figure 3. The demonstration plot is separated in two parts in which two types of farming is practised: one part under conservation agriculture, the other part under traditional agriculture. Both parts measure 25x10 metres and are separated from each other via walkways or small banks of mulch or plants. Along the borders of the demonstration field, plants such as Tithonia or Napier grass are cultivated.

The host farmers have volunteered a piece of land to be used as a demonstration field. This means that the allocation of a demonstration is not randomized. The location of the field is chosen due to availability, chance or due to proven high (or low) quality soil. By not randomizing the location of the fields, it's not certain whether the fields are representative for other fields in the region and, because of that, whether the results will be accurate. To reduce this effect, a variety of characteristics of the demonstration fields have been recorded.

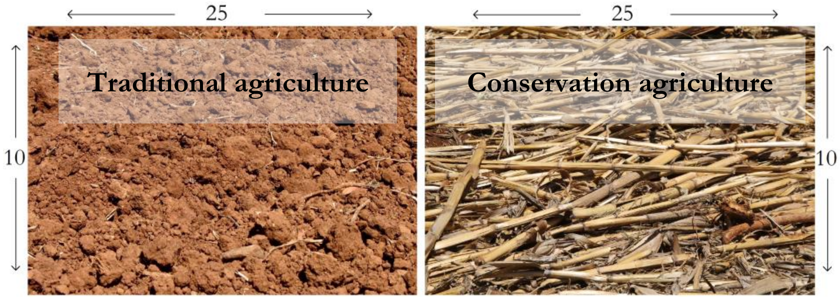

Figure 3: Design demonstration field[2]

2.3.5 Cultivation demonstration fields

To standardize the cultivation of the demonstration fields, a protocol has been set up to guide the farmer groups. This protocol is included in the Appendix. The protocol shows that the three basic principles of conservation agriculture are pursued: minimum soil disturbance, crop rotation and permanent soil cover. Furthermore, the protocol interdicts the use of synthetic pesticides on the conservation part of the demonstration field. The use of organic pesticides is encouraged, moreover because the farmers have been trained to make it themselves which could reduce production costs. However, during data collection, it proved that despite the protocol, the cultivation of the demonstration fields differs significantly (see Chapter 3).

[2] Source: Wallpaperweb.org (Nature Ploughed Field) and own archive

3. Research design, data and model

3.1 Data collection methods and sample

The data collection took place in February and March 2015, after the harvest of 2014 was collected. The data is collected using individual surveys and group discussions. Two types of surveys are used. To avoid any confusion, the two types of survey are referred to as survey A and survey B.

3.1.1 Survey A

Survey A includes questions about the respondent's socio-demographic characteristics, demonstration field characteristics (if that person is a host farmer of maize) and empowerment related questions. The survey is done with the help of six enumerators, one men and five women from Kapchorwa district. Prior to conducting the survey, they were trained in interviewing techniques and the design of the survey by staff of AT Uganda Ltd. and myself. Using a pilot study, the enumerators were able to gain experience with the survey. While conducting the interviews, the enumerators were supervised by the project officer of AT Uganda Ltd. and myself. Prior to arrival in a subcounty, the CBF of that particular subcounty was informed about the visit. The CBF helped the enumerators to locate the selected group members. The survey is written in English, but the enumerators performed the survey in the local language of Kupsabin. On average, the survey took 30 minutes. No compensation was provided for participating in an interview.

The sample frame of survey A is partly randomly sampled, and partly non-random. This division is made due to high heterogeneity among the groups and individual group members. Stratification was used during the sampling procedure. This means that the randomly selected respondents of survey A reflect the male / female ratio of the farmer groups, and that all farmer groups are represented. In total, survey A is conducted with 297 people. From these respondents, the non-random sampled respondents are 99 host farmers of maize and beans; 41 men and 58 women. The randomly selected sample consists of 198 respondents. From the randomly selected respondents, 152 are female and 46 are male.

3.1.2 Survey B

Survey B included questions about socio-demographic characteristics, demonstration field characteristics, characteristics of the cultivation of the field and the local market prices of inputs, maize and beans. The aim of this survey was purely to gather information about the characteristics- and the cultivation of the demonstration fields This survey is done with the help of two of the six enumerators who also worked on Survey A, one man and one women. Other procedures of Survey A also apply to survey B.

The sample of survey B is non-randomly sampled because only host farmers of maize have been interviewed. This implies that the socio-demographic characteristics are not representative for all project participants, but only applicable to host farmers within the project. In total, 139 host farmers are interviewed; 45 men and 94 women.

3.1.3 Group discussions

In the group discussion, a variety of topics was discussed: socio-demographic characteristics of attendants, the cultivation of the demonstration field and the local market prices of inputs, maize and beans. Moreover, the farmers discussed the benefits and disadvantages of conservation agriculture. The group was asked about whether they adopted one or more principles of CA on their own land (and if so, which principle(s)). The attendants were also asked about the adoption of group members who were not present during the discussion. Nine farmer groups were randomly selected for a 'check-up'. This means that the enumerators visited the land of the members of these groups to check whether they really use principle(s) of CA as they said they did. Finally, the discussion concluded with the question whether the attendants knew people, not part of the EWA project, who replicated principle(s) of CA on their land.

During the group discussions, three people were present to lead the discussion, to translate and to record all answers. The project officer of AT Uganda Ltd. led the discussion, and because the group discussions are done in the local language, a translator was needed for myself to record all answers in English. Both the project officer as the translator are men who originate from Kapchorwa district. From the 74 discussions, the translator led 26 discussions because the project officer fell sick. The design of the group discussion was fine-tuned in a pilot study. Prior to the discussions, the corresponding CBF from the group was informed about the visit. A discussion varied between 45 minutes to one hour. No compensation was provided for participating.

From the 100 farmer groups, 74 groups participated in a group discussion. Initially, all 100 farmer groups were supposed to be part of a discussion so no random sampling was used. Due to limitations in time, and approaching the end of the data collection period, it turned out that not all 100 groups could partake. This means that the 74 groups that took part in a group discussion are not randomly selected, but part of the sample because of other reasons such as a group's proximity to Kapchorwa town or a motorable road, availability or possibly performance. Moreover, the members of the group who attended a discussion are members who chose to come, not because it was compulsory or random sampled. This suggests that there could be a selection bias which should be taken into account when interpreting the results of the group discussions. As mentioned above, 74 groups participated in a group discussion with in total 680 members present; 178 men and 502 women. This means that $^2/_5$ of the project participants and almost $^3/_4$ of the farmer groups are included in this evaluation.

3.1.4 Yield

The yield data of maize is collected in the beginning of January 2015 by AT Uganda Ltd. From 184 demonstration fields, the yield of maize has been recorded. The cobs of maize (including the leaves) were hand-harvested and weighed. From 8 demonstration fields, the maize is sold fresh. This means that a farmer and a buyer agree on a certain sum, where after the buyer carries out all harvest activities. Unfortunately, these 8 demonstration fields can't be used for the analysis because the exact amount in kilograms is unknown. Due to high variation in the collected data, the outliers are excluded from analysis.

3.2 Descriptive statistics

The descriptive statistics provide an overview of the data that is collected. Moreover, insight will be gained in the characteristics of project participants, the farmer groups, demonstration fields and the difference in cultivation in agricultural methods. The variables presented in the descriptive statistics can be found in the Appendix.

3.2.1 Characteristics project participants

The descriptive statistics of the project participants are based upon the data that is collected with the randomly distributed survey A. Only the randomized interviews are used because they are representative for all the members. If the non-random interviews of the host farmers were included, this could lead to skewed results because they were purposely selected. Their characteristics can't be seen as representative for all project participants. As shown in Table 1, 76% of the interview respondents is female with an average age of about 41 years old. 49% obtained his or hers highest level of education on primary school, followed by 37% secondary and 16% no education at all. On average, 8% of the project participants continued education on a higher level. The majority, namely 83%, visits a Christian church on Sundays. 89% is married, either monogamous or polygamous. The average household contains 4 adults and 4 children less than 18 years old, but the number of children can vary between the zero and 18. A project participant cultivates roughly 1.72 acres (0.4 hectares) of land on which 47% generates income by cultivating maize.

In Table 1, there are seven variables labelled with an A or B. This letter represents the method of how this information is collected; using survey A (A) or a group discussion (B).
Exactly 75% of the group discussion participants was female, who were on average 40 year old. 78% is Christian. The majority, 49%, attended primary school, followed by 32% secondary school and 4% high level education. Around 14% did not go to school.

The variables are presented per data collection method to compare the means. Using a t-test, the comparison will show whether there is a selection bias regarding the attendants of the group discussion. The results of the test are included in the Appendix. There are three variables who significantly differ in means. In the group discussion, there are, on average, more people interviewed who followed primary education and less people who followed high level education. In addition, there were relatively less Christians present at a discussion than individually interviewed. That said, the differences in education and religion are small. Based on the results of the t-test, no selection bias is assumed for the attendants of the group discussions. Their socio-demographic characteristics will be used in the analyses.

3.2.2 Characteristics farmer groups

The data concerning the farmer groups is retrieved from the member registration lists of AT Uganda Ltd., updated during the time of data collection. From two groups, the member lists were uncertain so they are not included in this analysis. An average farmer group includes 18 people, but it can range between 7 and 38 members. From these people, on average, 75% is female, varying between 20% female members and only female. In total, there are 17 groups where only women are member. Finally, during 73 group discussions, on average 48% of the members of a group attended.

3.2.3 Characteristics demonstration fields

The check the comparability of the demonstration fields, the characteristics of the fields will be discussed. Starting with the average location of a demo field; 0.4 km from a motorable road, 0.3 km to the home of the farmer, 0.7 km to the nearest trading centre and 0.5 km from the nearest water source. However, this distances differ per demo field, from zero km to (in case of distance to a road) 10 km. 20% of the demonstration fields is located on a gentle or steep slope, where about two-third of the farmers chose for a non-parallel field orientation. This orientation means that either the CA or TA side is on the upper/lower side of field, contrary to a parallel field orientation where both the CA and TA side have an upper and lower side. The orientation of the demo field is important to note because it could influence the characteristics of the soil (water drainage, soil erosion) and therefore influence the yield. Speaking of erosion, approximately 22% of the demonstration fields is prone to soil erosion. Nevertheless, around 89% of the farmers rate the soil fertile or very fertile. The most common soil type (82%) is loam. 74% of the farmers reported the occurrence of a weather shock during the three previous years, and 84% reported a pest or disease which set upon the crops. The most common pests recorded are stalk maize borer, aphids, cut worms and rats. Along the demonstration field, 42% of the host farmers maintained a border. A border within the demonstration field, separating the CA and TA side, was done on only 36% of the fields. Finally, prior to the project, in 73% of the cases, the crop that was grown on the demonstration field was maize.

3.2.4 Characteristics cultivation

The characteristics of the cultivation of the demonstration field is discussed by: (1) The descriptive statistics per agricultural method and (2) a comparison between the two agricultural methods. The set-up of the comparison between CA and traditional agriculture is further explained in section 3.4.1 'Comparison cultivation characteristics'.

Within the project, intercropping maize with beans was encouraged. 89% of the host farmers planted beans (except one farmer who planted cabbage) as an intercrop. Unfortunately, many beans failed due to severe rain and wind. On the CA side of the demonstration field, 86% used slashing and/or mulching to prepare the land for planting. In theory, due to soil cover, no weeding is needed. However, 65% of the demonstration fields needed handpicking to remove the weeds. 77% of the host farmers left the residues on the field after harvest. On the TA side, almost everyone used a hoe or an ox plough to till the soil during land preparation (98%) or during weeding (97%)

Table 1: Descriptive statistics

Variable	No. observations	Mean	SD	Min	Max
(1) Characteristics project participants					
[A] if data collected with survey A [B] if data collected with group discussion					
Female [A] [3]	198	0.76	0.43	0	1
Female [B]	658	0.75	0.43	0	1
Age [A]	196	41.2	10.98	20	77
Age [B]	655	40.2	12.66	15	80
Education (none)[A] [4]	197	0.16	0.37	0	1
Education (none)[B]	658	0.14	0.35	0	1
Education (primary)[A] [5]	197	0.40	0.49	0	1
Education (primary)[B]	658	0.49	0.50	0	1
Education (secondary)[A] [6]	197	0.37	0.48	0	1
Education (secondary)[B]	658	0.32	0.47	0	1
Education (high)[A] [7]	197	0.08	0.27	0	1
Education (high)[B]	658	0.04	0.19	0	1
Christian [A] [8]	198	0.83	0.37	0	1
Christian [B]	657	0.78	0.41	0	1
Married [9]	197	0.89	0.31	0	1
Adults HH	193	3.76	2.21	0	11
Children HH	198	3.53	2.20	0	18
Farming maize [10]	179	0.47	0.50	0	1
Access to land	654	1.72	2.30	0	50
(2) Characteristics farmer groups					
Group size	98	18.47	6.94	7	38
Male/female ratio	100	0.74	0.21	0.2	1
Attendance GD	73	47.97	17.25	13.9	94.1

[3] 1 if interviewed project participant is female, 0 if otherwise
[4] 1 if interviewed project participant didn't go to school, 0 if otherwise
[5] 1 if interviewed project participant did go to primary school, 0 if otherwise
[6] 1 if interviewed project participant did go to secondary school, 0 if otherwise
[7] 1 if interviewed project participant did go to high level education, 0 if otherwise
[8] 1 if interviewed project participant is Christian, 0 if Muslim
[9] 1 if interviewed project participant is married, 0 if otherwise
[10] 1 if interviewed project participant generates income by cultivating maize, 0 if otherwise

(3) Characteristics demonstration field					
Distance road	191	0.41	0.81	0	10
Distance home	193	0.32	0.48	0	3
Distance trading centre	193	0.68	0.58	0	3.5
Distance water	191	0.46	0.42	0	3
Slope[11]	193	0.19	0.39	0	1
Non-parallel field orientation[12]	36	0.39	0.49	0	1
Erosion[13]	193	0.22	0.42	0	1
Soil type[14]	190	0.82	0.38	0	1
Soil quality[15]	193	0.89	0.32	0	1
Weather shocks[16]	193	0.74	0.44	0	1
Pests and diseases[17]	193	0.84	0.36	0	1
Previous crop[18]	192	0.73	0.45	0	1
Border field[19]	192	0.42	0.49	0	1
Border within field[20]	191	0.36	0.48	0	1

(4) Characteristics cultivation					
Land preparation method CA[21]	194	0.86	0.35	0	1
Land preparation method TA[22]	198	0.98	0.12	0	1
Intercrop[23]	198	0.89	0.31	0	1
Weeding method CA[24]	197	0.65	0.48	0	1
Weeding method TA[25]	196	0.97	0.16	0	1
Left residue use[26]	189	0.77	0.42	0	1

[11] 1 if slope is demo field is on gentle or steep slope, 0 if no slope
[12] 1 if set-up of demo field is not parallel (either CA or TA on upper /lower side), 0 if parallel
[13] 1 if there is soil erosion, 0 if otherwise
[14] 1 if the soil is loam, 0 if otherwise
[15] 1 if the soil quality is fertile or very fertile, 0 if otherwise
[16] 1 if there has been a weather shock in the past three years, 0 if otherwise
[17] 1 if there has been a pest and/or disease in the past three years, 0 if otherwise
[18] 1 if maize was grown on the demo field prior to the project, 0 if otherwise
[19] 1 if a border was maintained along the demo field, 0 if otherwise
[20] 1 if a border was maintained within the demo field, 0 if otherwise
[21] 1 if zero tillage (slashing and/or mulching) is used on the CA side, 0 if otherwise
[22] 1 if zero tillage (ploughing or hoes) is used on the TA side, 0 if otherwise
[23] 1 if there was intercropping, 0 if otherwise
[24] 1 if handpicking was done on the CA side, 0 if otherwise
[25] 1 if zero tillage (ploughing or hoes) is used on the TA side, 0 if otherwise
[26] 1 if residues left on the field after harvest, 0 if otherwise

3.4 Comparative analysis of CA and traditional agriculture

In this subsection, a comparative analysis of the different agricultural methods is done. The analysis consists of three parts. First, the mean values of the inputs and yields of CA and TA are presented and compared using a t-test. Subsequently, the labour and yield are analysed using a FE and RE model to examine the differences within and between the demonstration fields. The subsection concludes with a profitability analysis which will demonstrate the economic potential of the different agricultural methods.

3.4.1 Comparison characteristics cultivation

To analyse the distribution of inputs on the two sides of the demonstration field, a comparison is presented in Table 2. The comparison is based upon information from demonstration fields of which the yield data is known from. The mean values of the inputs, labour and yield are analysed using a t-test. Variables displayed in bold have means who are significantly different from zero.

The comparison shows that the average amount of seed is, for both CA and TA, 1.38 kg. The corresponding p value shows no statistical difference in the mean of seed. The same applies to the mean values of fertilizer (respectively 2.79 and 2.81 kg). The amount of organic and in-organic pesticides is identical on the two sides of the demo field. On average, 82 farmers used a little over 10 litres of organic pesticides while 24 farmers used roughly the same amount of inorganic pesticides per agricultural method. None of the farmers who are included in this sample use organic top dressing. 156 farmers used inorganic top dressing, for CA 2.89 kg and for TA 2.85 kg. The p value of 0.58 suggests no statistical difference in the mean. The protocol spacing variable represents whether the spacing of maize suggested by the protocol is followed through. On the CA side, 30% of the fields follow the protocol on spacing, while on TA side this is 30%. No statistical difference between the agricultural methods is found.

Table 2: Comparison CA and TA

Variable	**n**	**CA Mean value (SE)**	**TA Mean value (SE)**	**Difference in mean (p value)**
Seed	166	1.38	1.38	0.01
		(0.04)	(0.04)	(0.91)
Fertilizer	152	2.79	2.81	0.02
		(0.03)	(0.03)	(0.70)
Organic pesticides	82	10.88	10.04	0.85
		(0.45)	(0.45)	(0.19)
Inorganic pesticides	24	10.80	11.51	0.72
		(0.56)	(0.54)	(0.41)
Inorganic top dressing	156	2.89	2.85	0.04
		(0.05)	(0.04)	(0.58)
Protocol spacing[27]	165	0.30	0.30	0.01
		(0.04)	(0.04)	(0.32)
Labour land preparation	166	17.38	6.17	11.74
		(1.13)	(0.41)	(0.00)
Labour planting	167	9.39	5.64	3.74
		(0.91)	(0.35)	(0.00)

[27] 1 if spacing is according to protocol, 0 if otherwise

Labour weeding	166	15.68	5.76	9.92
		(1.08)	(0.31)	(0.00)
Labour pesticides	165	7.51	4.85	2.67
		(0.63)	(0.47)	(0.00)
Labour top dressing	166	2.05	1.92	0.12
		(0.17)	(0.15)	(0.578)
Labour harvest	166	9.15	11.08	1.92
		(0.61)	(0.58)	(0.02)
Maize yield	171	138.71	108.47	30.23
		(5.00)	(4.82)	(0.00)

As shown in Table 2, the amount of labour (in hours) used on the CA and TA side is separated in six phases: land preparation, planting, weeding, application of pesticides, application of top dressing and harvesting. On the CA side, land preparation includes the time spend to collect mulch. On average, almost 18 hours is needed to prepare the land on the CA side. 12 hours less are needed to prepare the land on the TA side of the demo field. Planting of maize requires around 9 hours on the CA side, and almost 6 hours on the TA side. The difference in labour could be caused by soil cover. On the CA side of the demo field, the mulch needs to be moved to create space for planting the seeds. During weeding, the number of hours working under CA are higher (15.7) than with TA (5.8). Spraying the demonstration field with (in)organic pesticides needs, on average, almost 8 hours of labour on the CA side, and 5 hours on the TA side. The application of top dressing is the only phase of labour that does not significantly differ in mean values; 2.05 hours with CA, 1.92 hours with TA. Finally, close to 11 hours is needed to harvest the maize on the TA side, compared to about 9.2 hours on the CA side. Only during harvesting, the amount of labour is higher on the traditional side than on the conservation agriculture side.

Figure 4 shows the average labour (in hours) on a demonstration field per cultivation phase. It confirms the findings presented in Table 2 that cultivation using CA principles requires more labour than TA. The average total amount of labour on the CA is almost double the amount than on the TA side (respectively 61 hours and 35 hours). Especially during land preparation and weeding, almost the double amount of labour is needed on the side of conservation agriculture.

Figure 4: Labour profile

What could contribute to this increased demand for labour on the CA side is that farmer groups mentioned more hours on the CA side of the demo plot because they included hours of trainings. During data collection, this effect was limited as much as possible but it could be that there are still hours of training included. Another possible explanation is due to the method of data collection. The cultivation characteristics are collected by recall of memory. Farmers had to estimate how much time they spend on the demo fields in the previous year. This could influence the accuracy of the actual hours spend on the demonstration field.

Another comparison concerns the average yield of 171 fields. Table 2 shows that under CA, an average of approximately 139 kg is harvested. The TA side produces almost 30 kg less, showing an average yield of 108 kg. Figure 5 presents the difference in yield between the two agricultural methods per demonstration field. The largest difference is measured at 104 kg, which means that on one demonstration field, the CA side generated 104 kg more yield than the TA side. On 18 fields, there is no difference in yield between the two agricultural methods. However, the majority of the demo fields show a positive difference in yield when using CA.

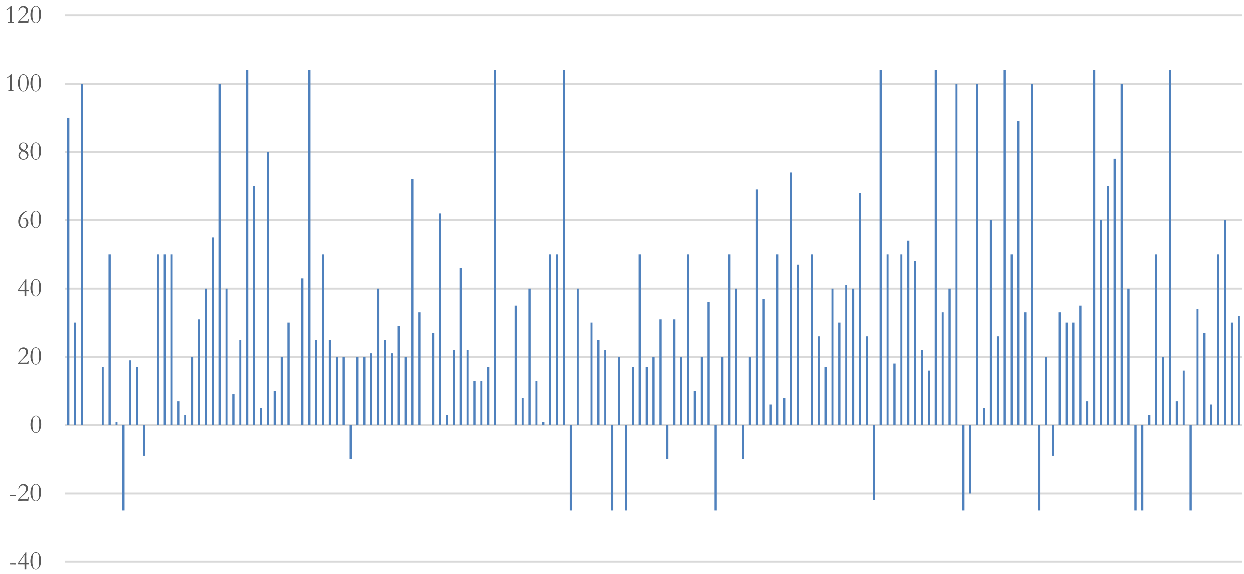

Figure 5: Difference yield CA and TA side per demonstration field

However, are these numbers comparable with the average maize yield in Uganda or Eastern Africa? That is difficult to say. The yield in the EWA project is measured as the weight of fresh cobs, while in most research the yield is measured as dry matter. Dry matter are the kernels of maize when removed from the cob and dried. In 2013, the average cereal yield (measured as dry matter) in Uganda was 2143 kg per hectare. (World Bank, 2015) On a demonstration field, that is approximately 53 kg per side.

Converting the demonstration field yields to dry matter yield is easier said than done. No literature or research can be found that has done so. However, the percentage of reduction of weight can be calculated. When using the World Bank data as benchmark, the weight of the yield on the CA side should be reduced by 62% and the weight on the TA side by 51%. One can decide for themselves whether this percentage seems is realistic or not. Personally, I think that the average yield of the demonstration fields is comparable with the average yield in Uganda regarding that the majority of the weight consists of the leaves and the cob itself (without the kernels).

3.4.2 Analysis yield and inputs

To analyse the relation between yield and the inputs presented in Table, a regression is done. The outcome of the estimation will help us to decide whether these variables should be included in the comparative analyses of yield and labour, discussed in subsection 3.4.3. The model is estimated as following:

$$Y_j = \beta_0 + \beta_1 INP_j + \beta_2 LBR_j + \varepsilon_j \quad (1)$$

where Y is yield in kilograms of demonstration field *j* (where *j* = 1,...., 171). The vector INP consists of the amount in kilograms of seed, fertilizer, top dressing and pesticides used on the demonstration field. The variables are transformed to quadratic variables because a non-linear relationship is assumed between these inputs and yield. The vector LBR represents all labour variables: land preparation, planting, weeding, applying pesticides, applying top dressing and harvesting in hours. β_0 is the constant and ε_j the error term. Linear regression will be used to estimate the model.

In this model, the focus of interpretation is on the two coefficients related to the vector of Inputs and Labour: β_1 and β_2. These coefficients will show whether there is a correlation between the work farmer groups have carried out on their demo fields, and the amount of yield it resulted in.

3.4.3 Comparative analysis of yield and labour

Further analysis of yield and labour is done using two types of models: a fixed effect (FE) and a random effect (RE) model. Both models are used to examine the variation on two levels: within a demonstration field, and between all demonstration field. The FE model will be used to examine the within variation of the demonstration fields. This means comparing the conservation agriculture, and the traditional agriculture side. The RE model will be estimated to examine the variation between the demonstration fields on a group- or regional level. First, the FE and RE model of yield are presented, followed by the two models of labour.

3.4.3.1 Comparative analysis of yield

The dependent variable in both the FE and RE model is Y_{jm}, the yield in kilograms where *m* indicates the agricultural method used on demonstration field *j*. The FE model is estimated as following:

$$Y_{jm} = \alpha_j + \alpha_1 CA_{jm} + \varepsilon_{jm} \quad (2)$$

where Y_{jm} refers to the yield of demonstration field *j* (where *j* = 1, ..., 171) per agricultural method *m* (where *m* = 0 if TA, 1 if CA). α_j is the demo field specific intercept. CA_{jm} is a dummy variable which takes unity in case the yield originates from the CA part of the demo field. ε_{jm} is the error term. The model is estimated using linear regression.

The second model, a RE model, is estimated to analyse the variation in yield between the demonstration fields. Several farmer group characteristics are included to explore the differences in yield.

$$Y_{ijm} = \alpha_0 + \alpha_1 CA_{jm} + \alpha_2 FG_{ij} + \varepsilon_{ijm} \quad (3)$$

where FG_{ij} refers to a vector of farmer group characteristics (where i = 1,...., 87). α_0 is the intercept and intercept and ε_{ij} the error term. The vector FG consists of farmer group characteristics such as Education, Age, Heterogeneity in terms of religion, Access to land, Male/female ratio, Group size and CBF. The model is estimated using linear regression taking clustered standard errors into account on group level.

3.4.3.2 Comparative analysis of labour

The set-up of the models described above are similar to the models that are used to analyse labour. The FE model of labour will compare the means of labour input between the CA and TA side of the demo field. The RE model is estimated to examine the variation in labour between all demonstration fields. The dependent variable in both the FE and RE model is L_{jm}, indicating the total amount of labour per agricultural method *m* used on demo field *j*. The FE model is estimated as following:

$$L_{jm} = \alpha_j + \alpha_1 CA_{jm} + \varepsilon_{jm} \quad (4)$$

where L_{jm} refers to the amount of labours in hours of demonstration field *j* (where *j* = 1,...., 171) per agricultural method *m* (where *m* = 0 if TA, 1 if CA). α_j is the demo field specific intercept. CA_{jm} is a dummy variable which takes unity in case labour is done on the CA part of the demo field. ε_{jm} is the error term. Linear regression will be used to estimate the model.

The fifth and final model is a RE model. This model is estimated to analyse the effect of farmer group *i* characteristics on labour between all demonstration fields:

$$L_{ijm} = \alpha_0 + \alpha_1 CA_{jm} + \alpha_2 FG_{ij} + \varepsilon_{ijm} \quad (5)$$

where FG_{ij} refers to a vector of farmer group characteristics (where *i* = 1,..., 87). α_0 is the intercept and intercept and ε_{ij} the error term. The vector FG is identical the one used in the RE model of yield. It includes Education, Age, Heterogeneity in terms of religion, Access to land, Male/female ratio, Group size and CBF. The model is estimated using linear regression with clustered standard errors on group level.

For Model (2) through Model (5), other variables concerning inputs and labour (described in Model (1)), can be included as well. Inclusion depends on whether the estimation results show significance, and more importantly correlation with the CA dummy variable. Endogeneity between the inputs and type of agricultural method can be expected, as the comparison of cultivation shows in Table 2.

Finally, when interpreting Model (2) through Model (5), the focus is on coefficient α_1 which is associated with dummy variable CA. This dummy variable indicates under which agricultural method the maize is cultivated. The other variables are included as control variables and added to find the true effect of conservation agriculture on yield or labour. However, there is always a possibility that there are variables that contribute to this effect but who are not included.

3.4.4 Profitability analysis

In the previous subsections, the focus of analysis is the amount of inputs and yield. In this section, the scope of analysis is extended to the associated price of an in- or output. A farm enterprise budget analysis is done to examine profitability of conservation agriculture compared to traditional agriculture. The analysis is based upon the work of Ngwira et al. (2012) and Mazvimavi and Twomlow (2009). To improve the comparability with other economic analyses of conservation agriculture, the prices are converted from Ugandan shilling to U.S. dollars using the official exchange rate at the time of analysis. The analysis is based upon the measurements of the demonstration field (25x10 meters per agricultural method). The information used in the analysis is collected during group discussions and survey B.

The research of Ngwira et al. (2012) and Mazvimavi and Twomlow (2009) determines production costs and profitability using standard enterprise budgeting techniques. In the analysis, four parts are distinguished: (A) Revenue, (B) Input costs, (C) Labour costs and (D) Returns. The returns consist of the gross margin, cost per kilogram and labour productivity.

Due to a large variation in yield and prices, the method of calculating the revenue, input costs and labour costs is adjusted. Instead of presenting the average of the amount of inputs of all demo fields and multiple it with the average price per input of all demo fields, this analysis is kept on the individual level. Per demonstration field, the amount of input or yield is multiplied with its local market price. The price of labour is collected per activity so the average hours of labour per person is used to estimate the total labour costs. All in all, the results of the profitability analysis in this paper are presented as averages of all demonstration field.

3.5 Analysis of adoption and replication CA

In this section, the level of adoption and the level of replication of conservation agriculture is analysed. The level of adoption refers to the number of project participants who use one or more principle(s) of conservation agriculture on their own land, while the level of replications refers to non-project participants who use principle(s) of CA on their land. First, an overview is given from the benefits and challenges of CA put forth by the project participants during the group discussions. This functions as an introduction to the analyses concerning the level of adoption and the level of replication.

3.5.1 Benefits and challenges of CA

During the group discussions, the participants were asked to put forth what they consider the benefits and challenges of CA are. The benefits and challenges described below are the result of what the group discussion attendants said, but coded in several categories. An overview of all benefits and challenges, and their corresponding category, are included in the Appendix.

Let's start with the benefits, listed from most-mentioned to least-mentioned during a group discussion. The most common benefit mentioned is the reduction of soil erosion when using CA principles. The principle of soil cover reduces erosion in multiple ways: it decreases the speed and force of water, direct sunlight and wind in the soil. Soil erosion is also reduced because of the principle of minimum tillage. The soil is hard which makes it less vulnerable to erosion.

The second most-mentioned benefit of CA is the increase of soil fertility. This increase is caused by the two principles of soil cover and minimum tillage. The soil cover leads to an increase in fertility because it helps to contain soil moisture, stimulate the presence of soil organisms such as worms and when the mulch decomposes, it adds nutrients to the soil. Moreover, the mulch keeps the fertilizer in place which reduces the leeching of fertilizer when there is heavy rain. Minimum tillage contributes to fertility because the soil structure is not disorganised, leading to an increase in soil organisms.

Another benefit of CA pointed out during the group discussions is that the principles of CA help to reduce weeds. Crop rotations helps to manage pests while mulch reduces the growth of weeds. In addition, the use of organic pesticides is seen as a benefit because it will not harm people and animals. The contribution of CA to the health of crops is best notable when comparing the two sides of the demonstration field. The crops on the CA side grow faster and vigorously, resulting in higher yields. Farmers suggest this is also the result of minimum tillage because the ground is firmer which increases the crop's resilience to wind. Moreover, the roots of the plants are not disturbed by ploughing. One group even noticed that the maize on the CA side tastes better than the maize on the TA side.

Finally, the last benefit that was frequently mentioned during the group discussions, is the ability of CA to reduce production costs. The use of organic, self-made, pesticides and fertilizer reduces costs and it is long lasting. Farmers argue that less labour is needed due to the principle of minimum tillage. Moreover, exact spacing of the crops simplifies work when either applying pesticides, or during harvesting or weeding. Interestingly, as shown in subsection 'Comparison characteristics cultivation', CA requires more labour during almost every cultivation phase. It is possible that farmers feel like it is less work because of a change in intensity of the required labour. Tilling the soil with ploughs or hoes is physically demanding, while gathering mulch or handpicking weeds requires less physical strength.

However, there are always two sides on a coin. During the group discussions also the challenges of conservation agriculture were discussed. Four main challenges were frequently mentioned during the discussions. The first is that mulch attracts animals. Termites and other insects hide in the mulch which can damage the crops. Moreover, the presence of these insects also attracts other animals such as chickens who uproot the mulch in their search of insects and seeds. The mulch also attracts rats who feed on seedlings and insects. Additionally, the mulch is a favourable habitat for snakes which is dangerous for people and livestock.

The following two challenges also concern the use of mulch. In most of the subcounties, mulching materials are scarce and the mulching materials available are also used for cooking, feed for life stock or used as building material. Moreover, collecting mulch and spreading it on the field is considered as time consuming. Usually, the farmers collect the mulch around their home. If their land is far from home, it is labour intensive to bring all this material to the land. The last challenge is that because of minimum tillage, the soil is very hard. Farmers have to wait until there has been sufficient rainfall to soften the soil for planting. This is undesirable because a delay in planting could lead to a reduction in yield.

The last described challenge of the use of CA is pest management. The self-made organic pesticides does not control all pests. Moreover, handpicking the weeds on the CA side of the demo field is harder because the weeds grow within the mulch making it hard to uproot. Moreover, the mulch can be a fire hazard in the dry season.

3.5.2 Level of adoption

In this subsection, the level of adoption of CA is analysed. The analysis consists of two parts: (1) Descriptive statistics of level of adoption and (2) Adoption intensity analysis. As mentioned above, the level of adoption refers to the number of project participants who use one or more principle(s) of conservation agriculture on their own land. These principles include, next to the three key principles of CA, other principles which were promoted during the EWA project. These principles are the use of organic pesticides and fertilizer, digging trenches, terracing, planting Napier grass and maintaining a kitchen garden. Especially the use of organic pesticides and fertilizer was encouraged. In total, 926 project participants have been asked whether they use one or more principles of conservation agriculture on their own land.

3.5.2.1 Descriptive statistics of level of adoption

From the 926 respondents, almost 88% declares to use one or more principle(s) of CA promoted during the project. As shown in Table 3, from these adopters, more than half (52.9%) adopted one principle of CA. About 37% adopted two principles and almost 10% adopted more than two. 1.6% of the respondents implemented the three key principles of CA (minimum tillage, soil cover and crop rotation).

The most popular principle to adopt is soil cover with approximately 53%, followed closely by organic fertilizer with 50.8%. Crop rotation is done by 38% of the adopters. Minimum soil disturbance is less popular with a percentage of just below 9%. The other principles, less promoted by the project, are adopted by almost 4% of the project participants.

Table 3: Proportion adopted principles of CA by project participants (in %)

	n = 926
Principles	**Proportion**
Minimum tillage	8.75
Soil cover (mulching)	52.53
Crop rotation	38.22
Organic pesticides	7.40
Organic fertilizer	50.80
Other principles promoted by EWA project	3.58
(e.g. Kitchen garden, digging trenches, terracing, planting Napier grass)	
No adoption	12.42
1 principle	52.90
2 principles	36.99
>2 principles	9.86
3 key CA principles	1.60
(e.g. minimum tillage, soil cover and crop rotation)	

When interpreting the level of adoption, it should be accounted for that during the EWA project extra inputs were handed out to demonstrate the use of CA on other crops. From the people who adopted one or more principle(s) of CA, just over 43% received inputs (seeds or fertilizer, or both) from the EWA project. This makes it harder to determine whether people decided to adopted principles of CA on their own land because of their own initiative or because they received these inputs.

Another aspect of the level of adoption is the scale of adoption. 524 of the adopters were asked about the total amount of land they have access to for agriculture, and how much land they use principle(s) of CA. Table 4 shows the five most popular proportion percentages of land under CA. About 27% cultivates all his or her land using CA principle(s). This is followed by about 18% who cultivates half of their land under CA. These numbers are also shown in Figure 7, where the total overview of the scale of adoption (in percentage points) is presented. Interestingly, exactly half of the respondents cultivates more than 50% of his or her land using CA, while the other 50% cultivates less than 50% of their land.

Table 4: Proportion percentage of land under CA (in %)

	n = 524
Percentage	**Proportion**
100%	26.53
50%	17.75
25%	9.16
33%	4.58
12.5%	2.86

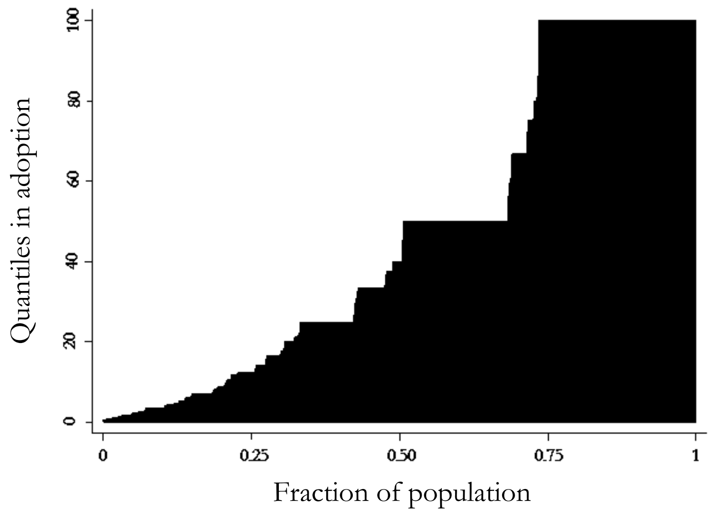

Figure 7: Scale of adoption

Reasons of why people use CA principles on parts of their land were also asked during the group discussion. All their motives, determined as a group, are included in the Appendix. Most frequently mentioned is that people want to try-out conservation agriculture, thus adopting only on part of their land to see whether there is a difference with their conventional practices. Another reason is that people consider collecting and spreading mulch on their land as it as too much work. Especially because mulching material can be scarce, which is also mentioned as a reason to not adopt full scale.

However, when people adopt principle(s) of CA, which crops are popular to use it on? 611 people were asked on which crops they use CA principle(s). The crops are categorised based on their growing season: whether the crop is harvested after one season, or whether it is cultivated for a longer period. For example, beans are harvested after a few months while banana plants provide fruits for a few years. The categorization of the crops is included in the Appendix.

Unfortunately, the exact information of which principle is used on which crop is not recorded. What is known is that 428 farmers grow only one-season crops, while 295 farmers solely grow long term crops. 122 farmers grow both one-season and more-than-one-season crops. These farmers are excluded from the analysis to examine whether there is a difference in the principles adopted per category of crop. The results of the remaining farmers is shown in Table 5. Organic fertilizer and soil cover are popular to use in combination with crops that are cultivated for longer than one season. Crops that can be harvested after one season, the principles of crop rotation, organic fertilizer and soil cover are most adopted.

Table 5: Proportion adopted principles of CA by crop (in %)

	n = 175	n = 308
Principles	**Proportion more-than-one-season crop**	**Proportion one-season crop**
Minimum tillage	8	7.5
Soil cover (mulching)	59.4	33.1
Crop rotation	5.7	58.8
Organic pesticides	5.7	3.9
Organic fertilizer	68	44.8

Of course there are also people who did not adopt principles promoted by the project. Table 3 shows that roughly 12% of the respondents said that they did not adopt. The most common motive is that somebody doesn't have access to land (22%). Either because they are too young to own land or because, in case of women, they just got married or were soon to get married. In Uganda, women get access to land by marriage. That said, just over 5% of the respondents, all women, indicated they did not adopt because their husband did not allow them. Other reasons project participants mentioned are lack of knowledge of CA because they recently joined a group (about 16%) or because they didn't attend the trainings (13.5%). Almost 7% argued that they just didn't see the benefits of CA. An overview of all mentioned motives of why people did not adopt can be found in the Appendix.

3.5.2.2 Analysis adoption intensity

Following the approach of Mazvimavi and Twomlow (2009), the second part of the analysis of the level of adoption focusses on the intensity of adoption. An ordered Logit model is used to measure the intensity of a farmer's adoption (the number of principles) and to examine factors that could contribute to a variation in the intensity.

During the EWA project, the focus has been on five principles[28]. However, the maximum number of adopted principles by the interviewed project participants are four principles. In the model, the dependent variable of adoption intensity is continuous and ordered between zero and four. This represents the number of principles adopted by the farmers. A farmer who didn't adopt any principle is assigned a score of zero, while a farmer who adopted four principles is ranked a four. Other farmers, who adopted one, two or three principles rank respectively one, two and three. Table 6 presents an overview of the number of observations per score. The majority of the farmers adopted one or two CA principles which is similar to the findings presented in Table 3.

Table 6: Number of observations per score

Score	Number of observations
0	2
1	429
2	300
3	70
4	10

Mazvimavi and Twomlow (2009) argue that '... the weight of adopting each component can be different given how easy or difficult each component is to apply'. To determine the weight of each principle is out of reach for this study, but by ranking the number of adopted principles (and not ranking the type of principle), this effect should be reduced.

The analysis of the intensity of adoption will be estimated using two models. Model (1) tries to capture the effect of a project participant' socio-demographic characteristics on the intensity of adoption.

$$ADOPT_{if} = \alpha_1 SDG_{if} + \varepsilon_{if} \quad (1)$$

where $ADOPT_{if}$ is discrete variable, ordered between zero and four representing the number of CA principles adopted by project participant *f* (where *f* = 1, …, 811) of farmer group *i* (where *i* = 1, …, 73). The vector SDG includes socio-demographic characteristics such as Gender, Age, Education, Religion and Access to land. No intercept is included in an ordered Logit model and ε_{if} is the error term.

Model (2) is an elaboration of Model (1) by including farmer group characteristics.

$$ADOPT_{if} = \alpha_1 SDG_{if} + \alpha_2 FGC_{if} + \varepsilon_{if} \quad (2)$$

where FGC_i refers to a vector of characteristics of farmer group *i* (where *i* = 1,..., 73) including Male/Female ratio, Heterogeneity in terms of religion, Difference yield CA and TA, Difference Labour CA and TA, and CBF.

[28] These five principles are minimum tillage, soil cover, crop rotation, organic pesticides and organic fertilizer. Excluded from this analysis are digging trenches, terracing, planting Napier grass and maintaining a kitchen garden.

3.5.3 Level of replication

In this section, the analysis focusses on replication: people who are not part of the project, but also started using ('replicating') one or more principle(s) of conservation agriculture. Unfortunately, the data that is collected about replication is limited, which means that an intensive analysis is not possible. However, the data that is collected provides an insight in the amount of replicated principles and the crops on which CA principles are used most frequently. From the people who are known to replicate one or more principles of conservation agriculture, just over 56% is male and 43% is female.

Identical to the summary of the proportion of principles adopted by project participants, the summary of proportion of principles replicated by non-project participants is presented in Table 7. The most popular principle is soil cover with about 56%, followed by organic fertilizer with around 40%. These are the same principles that are popular to adopt by project participants. The use of organic pesticides is not replicated at all. Minimum tillage is replicated by 2% of the non-project participants while almost 30% uses crop rotation.

Table 7: Proportion respondents practising principles of CA (in %)

	n = 144
Principles	**Proportion**
Minimum tillage [A]	2.08
Soil cover (mulching)[B]	55.56
Crop rotation [C]	29.17
Organic pesticides	0
Organic fertilizer	40.28
Other principles promoted by EWA project (e.g. Kitchen garden, digging trenches, terracing, planting Napier grass)	9.03

And finally, what are the crops that are popular to cultivate under CA? In the subsection of level of adoption, the crops are categorized based on their growing season (short or long). To sort out the differences of the use of principles of CA per crop type, the analysis solely included farmers who cultivate a crop in one category. Unfortunately, all replicating farmers grow both long- and short season crops which means that an analysis will not provide an insight in which principles are used on what crops.

4. Results

In the previous section, the design of the analyses are explained. This section presents the results of these analyses. First, the relationship between inputs and yield is, examined using a regression, are shown. The results of FE and RE models to analyse the differences of yield and labour within and between demonstration fields are presented subsequently. The farm enterprise budget analysis has linked inputs and prices to compare the profitability of the two agricultural methods. The section concludes with the outcomes of the adoption intensity model.

4.1 Analysis yield and inputs

The result of the analysis on the relationship between yield and inputs is presented in Table 8. The model is estimated using OLS. The output shows that there are five inputs who appear to have a significant relation with yield: the amount of seeds, fertilizer, pesticides, applying pesticides and the labour required for harvesting. The amount of seeds and fertilizer used on a demonstration field appears to increase the yield. A positive relation to yield also applies to the number of hours people spray pesticides, although the effect is very small. The amount of pesticides and the number of hours harvesting shows a negative relation to yield.

The residuals of the model are presented in the Appendix. The graph shows that there is a relation between the residual variances and the fitted values, suggesting heteroscedasticity. The model is estimated again after a log transformation of the labour variables to see whether the heteroscedasticity is due to a non-linear relationship between labour and yield. The amount of seeds, fertilizer, pesticides, and hours harvesting remain significantly different from zero, while the number of hours spraying pesticides is not significant anymore. The residuals of this model, also included in the Appendix, still display a pattern which indicates heteroscedasticity.

Although heteroscedasticity is found, the inputs will be included in the analysis of yield and labour because there are variables who show a significant relation with yield. This means that the inclusion could help examine the variation in yield and labour within and between demonstration fields.

Table 8: Yield and inputs

Dependent variable	**Yield**
Seeds[29]	6.144**
	(2.047)
Fertilizer[30]	5.426***
	(1.242)
Pesticides[31]	-0.066*
	(0.039)
Top dressing[32]	0.718
	(0.565)
Labour land preparation	0.196
	(0.402)
Labour planting	-0.407
	(0.464)
Labour weeding	0.423

[29, 30, 31, 32] A non-linear relationship is assumed between the amount used of these inputs and yield. The original variables of seeds, fertilizer, pesticides and top dressing are squared to display the non-linearity.

	(0.456)
Labour pesticides	0.890*
	(0.476)
Labour topdressing	-0.193
	(1.546)
Labour harvest	-1.253**
	(.480)
Constant	66.499**
	(13.688)
Observations	208
R2	0.213

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4.2 Comparative analysis yield and labour

The results of the FE and RE models, for both yield and labour, are presented in Table 9. All models are estimated using OLS. The RE models take standard clustered standard errors on group level into account. Across all estimated models, there is a statistically significant and positive relation between the use of conservation agriculture and the amount of yield and labour.

4.2.1 Comparative analysis of yield

Without the inclusion of inputs and group characteristics, the yield is estimated to be almost 30 kg higher on the side of the demonstration field where CA is used (column 2). When the inputs are included, this positive effect of yield reduces to 24 kg. As column 3 shows, the inputs itself do not appear to have a relation with yield, with the exception of the number of hours spend on land preparation. So although positive relations between yield and the use of inputs was found in subsection 4.1, when including the dummy variable of CA, these relations are not found. This indicates that the type of agricultural method appears to have a larger effect on yield, than the amount of inputs used.

The results of the RE model in column 4 suggest that when comparing the yield between all demonstration fields, the total amount of maize yielded from the CA side is higher than the TA side. This is comparable with the results found in column 2. There is no evidence that the inclusion of group characteristics has an effect on yield, with the exception of the CBF dummy variables. Six of the CBFs are reported to have a statistically significant relation with yield, both positive and negative. From these six CBFs, there are two CBFs who guide all ten groups within their subcounty which suggests that the effect could also be the result of their location. To control for this, the same RE model is estimated but instead of CBFs, subcounty dummies are included. The results, presented in the Appendix, show that there are four subcounties who have an effect on yield. This includes the two subcounties in which the CBFs works alone. As the output shows, the size of the effect on yield is in these subcounties also the largest. Further implications of these findings are discussed in combination with the model presented in column 5.

This model is an extension of the previous ones because it also includes inputs. The positive effect of the use of CA on yield stays robust. A weak relation is found between the hours of harvesting and the use of CA, which is consistent with the descriptive statistics where the amount of labour required for harvesting was higher when using traditional agriculture. What is most interesting of these results is that the inclusion of inputs has led to a change in the relation between yield and the CBFs. With the exception of two CBFs, the relationship has increased dramatically but the standard deviation has increased as well. The exceptions are the two CBFs who guide all ten groups. To the contrary, their positive impact on yield has reduced.

Similar to the previous model, the model is estimated again with subcounty dummies. The results show that there are relations found between three subcounties and yield, of which two are the subcounties in which all then groups are supervised by one CBF.

The implications of these findings is that, based on the estimated models, it difficult to distinguish whether the relation to yield is due to the CBF, the subcounty or another variable that is closely related. For instance, two of the subcounties who are found significantly different from zero in both models are subcounties with the highest levels of altitude. Additionally, the estimates of the relation between CBF and yield appear not to be robust, differing in size (and standard deviation) when including additional variables. What could help to clarify these intertwined relationships are to gather more specific information about subcounties (such as average yield, rainfall and temperature) and CBFs (education, hours supervising). This information could help to distinguish and explain the variances in yield.

4.2.2 Comparative analysis of labour

Without the inclusion of group characteristics, the model in column 6 shows that there are 25 more hours of labour required on the CA side of the demonstration field. This increase in hours stays consistent when including inputs. None of the inputs appears to have a relation with labour (column 7). That said, an increase of 25 hours may not sound as much when the average farmer group has 18 members. However, the size of the CA side of the demonstration field is only 0.062 acres (25x10 meters) which means that when a farmer would start using CA on their own land, estimated at an average of 1.72 acres, this would have serious implications for the pressure on labour.

The increase in labour reduces with 2 hours when several group characteristics are included (column 8). Interestingly, the total number of hours of labour increases in case a group is homogeneous in terms of religion, either Christin or Muslim. A possible explanation for this relationship cannot be given based on the available data. Labour also increases with the average access to land which feels counterintuitive. Hence, when farmers have more land to cultivate, the less time they will be able spend on the demonstration field. A weak negative statistical significant relationship is found between the ratio of female members in a group and the number of hours spend on the demonstration field. So labour decreases when the ratio of female members in a group increases. In Uganda, women are expected to work in the fields, as well as at home. It is possible that in groups with more women the amount of time spend is lower because they already have a lot of work at home such as preparing food or taking care of the children. Giller et al. (2009) warn that conservation agriculture could increase the labour burden for women because of the shift in male-related tasks as ploughing to weeding which is mainly done by women. The relation between labour and the group characteristics described above stay significantly different from zero when inputs are included in column 9.

Column 9 depicts a relation between the total number of cultivation hours and seven CBFs, of which four highly significant. Remarkably, from these four CBFS, three appear to reduce the time working on the field, while simultaneously producing a higher yield (column 4 and 5). Once again, the model is estimated with subcounty dummies replacing the CBF dummies. The subcounties in which the three CBFs work who reduce labour while increasing yield are found highly significant, indicating that there appears to be a regional characteristic which reduces the time spend on the demonstration field.

The final model that is estimated includes inputs and group characteristics. None of the inputs are found to be related to the amount of labour which supports the findings in column 7. The number of significant relations between CBFs and time spend working on the field remains consistent. Only the size of the effect changes slightly.

Similar to the findings of the yield models, it is hard to attribute the effect on labour to either the CBF, the subcounty, or another variables that is not included. To check for omitted variable bias, the model is estimated while dropping the variables one by one. The estimates, and their found significance, change which suggests a bias. Additional information is needed to reduce or eliminate omitted variable bias. What could help is to gather more specific information about subcounties (such as average time spend on the field) and CBFs (hours of trainings given to groups).

Table 9: Comparative analysis yield and labour

Model	**FE (2)**	**FE (3)**	**RE (4)**	**RE (5)**	**FE (6)**	**FE (7)**	**RE (8)**	**RE (9)**
Dependent variable	**Yield**	**Yield**	**Yield**	**Yield**	**Labour**	**Labour**	**Labour**	**Labour**
CA	30.233***	24.610***	30.762***	29.310***	24.519***	24.857***	22.815***	22.137***
	(2.629)	(4.861)	(4.023)	(6.929)	(2.500)	(3.523)	(3.177)	(4.467)
Seeds		2.960		6.201**		-10.536		0.981
		(19.545)		(3.011)		(19.730)		(1.602)
Fertilizer		0.679		1.070		3.115		-0.182
		(5.585)		(1.632)		(5.792)		(0.729)
Top dressing		-0.370		-0.316		0.166		0.129
		(0.491)		(0.357)		(0.413)		(0.165)
Pesticides		0.035		0.005		-0.042		-0.024
		(0.048)		(0.031)		(0.049)		(0.027)
Labour land preperation		0.643**		0.559				
		(0.322)		(0.318)				
Labour planting		0.492		0.244				
		(0.342)		(0.478)				
Labour weeding		-0.496		-0.399				
		(0.320)		(0.297)				
Labour pesticides		-0.191		-0.155				
		(0.331)		(0.395)				
Labour top dressing		2.740		1.207				
		(2.293)		(1.559)				
Labour harvest		-1.323		-1.039*				
		(0.826)		(0.578)				
Religion			8.854	10.782			19.879**	25.547**
			(12.482)	(21.466)			(6.541)	(8.400)
Education			1.972	-2.262			2.414	-1.441
			(7.420)	(10.139)			(3.503)	(4.298)
Age			0.623	1.058			0.120	0.228
			(0.649)	(0.999)			(0.352)	(0.512)
Male / female ratio			-1.878	-27.722			-22.378*	-38.675**
			(24.366)	(40.247)			(13.584)	(15.443)
Access to land			-5.898	-10.890			6.846**	6.324*
			(4.047)	(7.782)			(2.185)	(3.645)
Group size			-0.187	0.252			0.104	0.330
			(0.678)	(1.055)			(0.369)	(0.512)
CBF 2			-17.262	-48.817*			-112.926	0.617
			(13.831)	(25.441)			(14.868)	(17.108)
CBF 3			39.439	35.162			-7.045	-5.150
			(27.621)	(36.109			(13.895)	(17.392)
CBF 4			-34.585*	-45.189**			16.136*	13.068
			(14.774)	(18.649)			(8.742)	(10.398)
CBF 5			-30.106	-46.756**			6.487	13.900
			(17.147)	(23.178)			(14.648)	(12.800)
CBF 6			23.154	11.446			-14.914	-24.226**
			(19.425)	(23.801)			(9.801)	(11.396)

CBF 7			29.108*	27.078			11.022	8.334
			(15.889)	(21.676)			(9.056)	(9.187)
CBF 8			21.160	8.906			-2.819	-32.334
			(20.245)	(37.113)			(18.845)	(20.048)
CBF 9			154.958***	131.445***			-22.524*	-20.480*
			(34.137)	(28.239)			(11.819)	(11.631)
CBF 10			30.379	28.833			-13.978	-13.543
			(31.441)	(41.375)			(9.086)	(10.791)
CBF 11			4.613	-9.375			-25.001**	-32.601**
			(18.456)	(28.779)			(9.252)	(11.842)
CBF 12			-55.062**	-77.128**			-33.957***	-39.867***
			(18.336)	(30.475)			(9.599)	(11.271)
CBF 13			41.691*	40.811			-8.117	-5.653
			(24.676)	(34.717)			(14.895)	(19.354)
CBF 14			61.641***	49.155*			-39.341***	-31.228*
			(15.988)	(27.562)			(10.701)	(117.356)
CBF 15			15.789	12.378			-35.839***	-39.313***
			(19.044)	(27.627)			(9.094)	(9.823)
CBF 16			133.605**				-38.722***	
			(39.812)				(10.802)	
Constant	108.474***	98.760***	62.432	73.156	37.480***	41.265**	27.508	43.358
	(1.859)	(19.166)	(45.996)	(79.153)	(1.758)	(19.280)	(24.863)	(32.150)
Observations	342	208	244	146	317	208	228	146
R2 within	0.438	0.547	0.409	0.532	0.383	0.353	0.366	0.318
R2 between	0.000	0.018	0.679	0.729	0.028	0.008	0.337	0.386
R2 overall	0.053	0.067	0.645	0.701	0.133	0.043	0.350	0.349

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The observations differ per model because of missing socio-demographic. group or cultivation data

4.3 Profitability analysis

Inputs and prices are linked in a farm enterprise budget analysis to compare the profitability of the two agricultural methods. The analysis is discussed per subsection: revenue, input costs, labour costs and returns. The results are presented in Table 10.

On average, the revenue of the CA side of the demo field is $4.81 higher than the revenue from the TA side. The local market price for maize doesn't differ per yield so the difference in revenue can only be explained by the amount of yield.

The inputs costs are quite similar for both agricultural methods with a difference of $0.07. The costs of seeds on the TA side are slightly higher because more seeds are used, and thus higher costs. This is also the case for the costs of fertilizer. The costs of organic pesticides and top dressing are estimated at zero because no information is collected about possible opportunity costs. The costs for applying the pesticides are taken into account. In addition, the descriptive statistics has shown that no statistical difference is found between the quantity of pesticides and top dressing used between agricultural methods.

The estimated labour costs differ per agricultural method. The difference is mainly the result of the hours spend during land preparation. The price of land preparation is almost $2 higher on the CA side, because more hours of labour were required. This is contrary to the research of Siziba (2008) and Kassam, Friedrich et al. (2009) who argue that because of minimum tillage, conservation agriculture will help to reduce the amount of labour. The price of weeding, applying pesticides and top dressing is quite similar for both methods. This is remarkable because the total hours of labour of weeding were found to be statistically different from each other. Apparently, the price of weeding using tillage (plough or hoe) is cheaper than collecting and spreading the mulch. Although the costs of planting are slightly higher on the TA side, the total labour costs are almost $2.5 higher for conservation agriculture. Higher labour costs associated with the use of CA conservation agriculture are also found by Mazvimavi and Twomlow (2009). However, the estimated gross margin of cultivating maize under CA principles is almost 2.5 times higher than using TA. The costs of producing one kilogram of maize is 0.02 cent higher when using traditional agricultural methods. So even though the variable costs for TA were lower, because of the lower revenue (due to lower yield), the production costs are higher. Finally, the output shows that the labour productivity is higher on the CA side. On average, one hour cultivating a field with CA principles would result in approximately one kilogram more maize than working one hour cultivating a field with traditional principles.

These findings on returns is in line with Mazvimavi and Twomlow (2009) and Ngwira et al. (2012) who found higher gross margin, cheaper costs of producing a kilogram of maize and higher returns to labour under conservation agriculture in respectively Zimbabwe and Malawi

Table 10: Farm enterprise budget analysis

Variable	**Price per unit**	**CA**	**TA**
		Amount (US$)	Amount (US$)
(A) Revenue			
Maize	kg	23.20	18.39
(B) Input costs			
Seeds	kg	3.17	3.22
Fertilizer	kg	2.29	2.30
Organic pesticides	liters	0.00	0.00
Inorganic pesticides	liters	2.19	2.19
Inorganic top dressing	kg	2.09	2.10
Total input costs		9.74	9.81
(C) Labour costs			
Land preperation	hrs	5.67	3.40
Planting	hrs	0.72	0.85
Weeding	hrs	0.95	0.94
Pesticides	hrs	0.37	0.37
Top dressing	hrs	0.14	0.17
Harvest	hrs	1.34	1.48
Total labour costs		9.19	7.21
Total variable costs		18.93	17.02
(D) Returns			
Gross margin	US$/Side demo field	3.37	1.37
Cost per kg	US$/Side demo field	0.13	0.15
Labour productivity	kg/hour	33.88	32.97

4.4 Analysis adoption intensity

An ordered Logit model is estimated to examine the level of adoption of CA principles among the project participants. Socio-demographic and group characteristics are included that can affect the variation in intensity. All regressions are estimated using standard cluster standard errors on group level. Table 11 presents the results of the analysis. The left side of the graph shows the results of the logistic regressions, while the right side displays the corresponding marginal effects.

Within the socio-demographic control variables, there are two variables who have a consistent statistically significant relationship with the number of adopted CA principles. The age and level of education have a positive relation, indicating that the number of adopted principles increases when a project participant is relatively older and well-educated. Older people will probably have more land on which they can use conservation agriculture. Moreover, they will have more experience in farming which Giller et al. (2009) considers as one of the factors that increase the likelihood of adoption.

Female project participants appear to adopt less principles of CA, but this result is not consistent in all models (only column 2 and 5). The reason that women appear to adopt less principles than men could be due to land ownership. The majority of (agricultural) lands in Kapchorwa and Kween districts are owned by men which makes them in control of the agricultural practices. This is illustrated during the group discussions when several women argued that they didn't adopt any principles because their husband did not allow them.

A small negative relation is reported between the number of adopted CA principles and the difference in hours cultivating the separate sides of a demonstration field. As the difference in labour increases, the intensity of adoption is estimated lower. One can imagine that when the farmers notice a new agricultural method requires much more labour than their traditional practices, it becomes less attractive to adopt (Pannell et al., 2006). Interestingly, the difference in yield between the two agricultural methods does not appear to have a relation with the number of adopted principles.

In column 5, CBF dummy variables are inserted to examine the relation between adoption intensity and the supervision that groups have received. Only two relations are found. What is most remarkably of these results is that these CBFs are also related to the groups who yielded the most maize. Moreover, it is also the CBF of which groups spend less time cultivating the demonstration field.

To examine whether the adoption intensity is related to the CBF or to other regional characteristics, the model is estimated with subcounty dummies. The results are included in the Appendix. The estimation shows that the negative relation with the number of principles is underlined when including the subcounty dummies. The two subcounties in which the mentioned two CBFs work, overall less principles are adopted. This means that the negative relation cannot be solely attributed to the CBF, but seems more like a regional effect.

Finally, the cut off points within all models are significantly different from each other implicating that the use of four categories of adoption intensity is statistically justified.

To determine the exact relation of adoption intensity, the marginal effects of all models are presented in columns 5, 6 and 7. These marginal effects show the probability of a project participant to switch up to the next cut off point (or in this case, switching to a higher intensity of adoption) when a socio-demographic or group variable increases with 1 unit (keeping all other variables equal). The marginal effects are all negligible small (< 1%) which influences the level of statistical significance because none of the marginal effects are found to have a significant relation with the level of adoption.

Table 11: Analysis adoption intensity

Model	Logit (2)	Logit (3)	Logit (4)	Marginal effects (5)	Marginal effects (6)	Marginal effects (7)
Dependent variable	**ADOPT**	**ADOPT**	**ADOPT**	**ADOPT**	**ADOPT**	**ADOPT**
Female	-0.341*	-0.353	-0.419*	0.0011	0.0013	0.0030
	(0.19)	(0.240)	(0.229)			
Age	0.020**	0.030**	0.0301**	-0.0001	-0.0001	-0.0010
	(0.009)	(0.0102)	(0.01)			
Education	0.202**	0.205**	0.248**	-0.0007	-0.0008	-0.0081
	(0.064)	(0.0753)	(0.075)			
Religion	-0.169	-0.250	-0.144	0.0006	0.0009	0.0004
	(0.297)	(0.2639)	(0.417)			
Access to land	0.045	0.013	0.028	-0.0001	-0.0000	-0.0001
	(0.059)	(0.0219)	(0.02)			
Female ratio		0.151	-0.338		-0.0006	0.0011
		(0.8299)	(1.011)			
Homogeneous religion		-0.245	0.351		0.0009	-0.0011
		(0.2607)	(0.348)			
Difference yield		0.006	0.001		-0.0000	0.0000
		(0.005)	(0.007)			
Difference labour		-0.007	-0.014*		0.0000	0.0005
		(0.0047)	(0.006)			
CBF 2			-1.122			0.0037
			(0.693)			
CBF 3			-0.031			0.0001
			(0.824)			
CBF 4			0.259			-0.0008
			(0.923)			
CBF 5			-0.641			0.0021
			(0.794)			
CBF 6			-0.935			0.0031
			(1.027)			
CBF 7			0.711			-0.0023
			(0.808)			
CBF 8			-0.347			0.0011
			(0.736)			
CBF 9			-0.757			0.0025
			(0.602)			
CBF 10			0.156			-0.0005
			(0.696)			
CBF 11			-0.917			0.0030
			(0.716)			
CBF 12			-0.427			0.0014
			(0.707)			
CBF 13			-0.991			0.0032

			(0.866)	
CBF 14			-1.818**	0.0059
			(0.608)	
CBF 15			-1.776**	0.0058
			(0.675)	
CBF 16			-0.771	0.0025
			(0.563)	
Cut-off point 1	-4.557	-4.158	-5.042	
	(0.896)	(1.122)	(1.326)	
Cut-off point 2	0.991	1.248	0.498	
	(0.612)	(.957)	(1.102)	
Cut-off point 3	3.168	3.500	2.879	
	(0.612)	(.943)	(1.054)	
Cut-off point 4	5.363	5.892	5.335	
	(0.717)	(1.004)	(1.157)	
Observations	556	454	454	

* p < 0.10, ** p < 0.05, *** p < 0.01. A t-test on the cut off points shows that for every model. the cut off points are significantly different from zero

5. Conclusion

In 2012, the 'Empowerment of Women – Benefit (for) All' (EWA) project started in two districts in Eastern Uganda. The aim of the project is to empower small scale farmers by gaining knowledge and experience in conservation agriculture. NGOs Women in Europe for a Common Future (WECF) and AT Uganda Ltd. established 100 demonstration fields of maize intercropped with beans. Within a demonstration field, there are two agricultural methods used: one part of the field conservation agriculture (CA), and one part traditional agriculture (TA). CA is an agricultural method based on three key principles: minimum soil disturbance, soil cover and crop rotation (Friedrich, Derpsch et al. 2012). In addition, the project promoted the use of organic pesticides and fertilizer. Each demonstration field is cultivated by a local farmer group. In total, around 2000 women and men are involved in the project.

By pulling together group discussions, individual surveys and yield data of the demonstration fields of 2014, this paper presents an evaluation of the EWA project. The evaluation of the EWA project is divided into two sections: (1) A comparative analysis of the performance of conservation agriculture within this project and (2) an analysis of the adoption and replication of principles of CA.

The first interesting finding of the comparative analysis of the performance of CA is the fact that the yield on the CA side is significantly higher compared to the traditional side, regardless of the amount of inputs used. This positive relation is consistent across all estimated FE and RE models. There is no evidence that the included group characteristics (e.g. religion, education, age, male/female ratio, access to land, group size) have an effect on yield, with the exception of the CBF dummy variables. However, when checked with the CBFs corresponding subcounties, it appears that the relation between yield and CBF is more likely to be the result of some regional characteristic. For instance, two of the subcounties with a positive relation with yield are the highest elevated subcounties within Kween and Kapchorwa districts.

However, the increase in yield when using CA comes with a price. All FE and RE models estimated for labour show a highly significant positive relation between the use of CA and the amount of hours worked on that particular side of the demonstration field. Interestingly, during group discussions the participants claimed that one of the benefits of CA is that less labour is needed. This discrepancy could be the result of a change in the intensity of labour. Collecting mulch is requires less physical strength than ploughing or hoeing. A weak negative relation is found between the ratio of female members in a group, and the number of hours spend on the demonstration field. In Uganda, women are expected to work in the fields, as well as at home. It is possible that in groups with more women, the number of hours is lower because they spend more time at home compared to their fellow male group members. That said, it should be noted that the total increase in labour is mostly due to an increase in labour during land preparation and weeding. Giller et al. (2009) warn that conservation agriculture could increase the labour burden for women because of the shift in male-related tasks as ploughing to weeding which is mainly done by women. The last remarkable finding of the labour analysis is that CBFs who appear to have a positive effect on yield, simultaneously reduce the labour required for cultivation. Once again, the inclusion of subcounty dummies implicates that there appears to be a regional characteristics which reduce the total hours of labour.

To estimate whether the benefits of a higher yield outweigh the increased hours of labour, a farm enterprise budget analysis is carried out to compare the profitability of the two agricultural methods on an average demonstration field. As expected, the revenue and labour costs are higher on the CA side. This leads to a higher gross margin, cheaper costs of production a kilogram of maize and higher returns on labour which is in line with research of Mazvimavi and Tomlow (2009) and Ngwira et al. (2012).

The second part of the project evaluation focuses on the adoption and replication of the principles of CA. Adoption refers to the number of project participants that has adopted one or more principle(s) of conservation agriculture on their own land. Replication is when non-project participants start using principles of CA on their own land.

From the interviewed project participants the majority (almost 88%) adopted one or more principle(s) of CA. From these people, almost half received inputs from the project (seeds or fertilizer) which makes it difficult to determine whether people adopted principles of CA due to own initiative or because they received these inputs. The most frequently adopted principle is soil cover. Interestingly, during the group discussions, soil cover using mulch was mentioned as one of the biggest challenges of CA due to its competition in use as fuel or animal feed. Research of Giller et al. (2009), Knowler and Bradshaw (2007) find consistent results in regarding the use of mulch as one of the limitations in the adoption of CA.

An ordered Logit model identifies that both the age and education level of project participants have a positive influence on the number of adopted principles. Older people with education are assumed to have more land to practice CA than young uneducated project participants. Women adopt less principles of CA which can be due to primarily male land ownership in Uganda. Men control what happens on the land which is illustrated during group discussions where women argued they didn't adopt any principles because their husband did not allow them. The last remarkable result of the adoption intensity analysis is that certain CBFs or subcounties (once again, it is hard to attribute this relation) reduce the number of adopted principles. This is remarkable especially when considering that the same CBFs or subcounties are also related to higher yield and less labour. Lastly, there are also people who did not adopt any principles promoted by the project. The most common motives are that people don't have access to land or because they believed they didn't acquire sufficient knowledge about CA.

During group discussions, the attendant were asked whether they know people, not part of the project, who use one or more principles of CA. In total, 44 people were mentioned. Similar to adoption, the most popular replicated principle is soil cover. Unfortunately, no further information is collected about the motives or characteristics of the people who replicate.

To conclude, there are some limitation to this evaluation. First of all, the location of the demonstration fields were not randomly chosen so it's not certain whether the fields are representative for other fields in the region, and, because of that, whether the results are accurate. Collecting yield and input information from other plots (not part of the project) could act as a reference to examine whether the variation in yield and labour can only be found on the demonstration field, or also elsewhere in the region. Gathering additional information should also be done to improve our understanding of why specific variables (CBFs and subcounties) appear to increase yield and labour. Based on the data collected for this evaluation, no final answer can be given of why this relationship is found. Another limitation is that data collection is done after cultivation. Recalling how much hours a farmer spend on, for example applying pesticides, last year, can be difficult to estimate. It's also possible that people over reported the number of hours to give social desirable answers. The accuracy of the analysis of labour use on the demonstration field could be improved by observing the time used for cultivation, instead of relying on recall information. Finally, the reported hours of labour can be biased when hours of training are included. During data collection, it is tried to filter out this effect as much as possible but it could still influence the accuracy of the actual hours spend cultivating the demo field. Finally, in terms of adoption, there is no guarantee that people adopted as a direct result of the EWA project. There is the possibility that farmers already used these principles, or started using them but learned about it elsewhere.

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Appendix A

Tables and figures

Table A1: Definition variables

Variable	Definition	Question	Answer	Method
(A) Characteristics project participants				
Female	The gender of participant. In regression, the variable is a dummy variable taking unity if participant is female, zero if male	N/A	1. Male 2. Female	A, B, C
Age	Age measured in years	What is your age?	In amount	A, B, C
Education (None)	Participant received no education. In regression, the variable is a dummy variable taking unity if participant doesn't have education, zero elsewhere.	What is your education?	1. None 2. Some primary 3. Completed primary 4. Some O level 5. Completed O level 6. Some A level 7. Completed A level 8. Tertiary institution 9. University	A, B, C
Education (Primary)	Participant followed some, or completed primary school. In regression, the variable is a dummy variable taking unity if participant went to primary school education, zero elsewhere.	What is your education?	1. None 2. Some primary 3. Completed primary 4. Some O level 5. Completed O level 6. Some A level 7. Completed A level 8. Tertiary institution 9. University	A, B, C
Education (Secondary)	Participant followed some, or completed secondary school. In regression, the variable is a dummy variable taking unity if participant went to secondary school education, zero elsewhere.	What is your education?	1. None 2. Some primary 3. Completed primary 4. Some O level 5. Completed O level 6. Some A level 7. Completed A level 8. Tertiary institution 9. University	A, B, C
Education (High)	Participant continued education on a tertiary institution or university. In regression, the variable is a dummy variable taking unity if participant followed higher education, zero elsewhere.	What is your education?	1. None 2. Some primary 3. Completed primary 4. Some O level 5. Completed O level 6. Some A level	A, B, C

			7. Completed A level 8. Tertiary institution 9. University	
Christian	What kind or religion a participant is. In regression, the variable is a dummy variable taking unity if member is Christin, zero elsewhere.	What is your religion?	1. Christina 2. Muslim 3. Other, specify	A, B, C
Married	The status of a participant's relationship. In regression, the variable is a dummy variable taking unity if participant is married, zero elsewhere.	What is your marital status?	1. Single 2. Relationship 3. Married monogamy 4. Married polygamy 5. Divorce / separated 6. Widow	A
Adults HH	Number of people 18 years or older in household (HH)	How many adults are in your household?	In amount	A
Children HH	Number of people younger than 18 years in household (HH)	How many children are in your household?	In amount	A
Farming maize	The type of crops that a participant cultivates. In regression, the variable is a dummy variable taking unity if member cultivates maize, zero elsewhere.	What type of crops do you farm?		A
Access to land	The amount of land a participant can use for farming	How much land do you have access to for farming?	Amount in acres	B,C
(B) Characteristics farmer groups				
Group size	The number of members of a farmer group. This is calculated using the member registration lists.	N/A	In amount	D
Male/female ratio	The ratio of male/female in a farmer group. In regression, variable is a percentage of the number of women who are member of a group.	N/A	In percentage	D
Attendance GD	The percentage of members of a group who attended the group discussion. This is calculated by dividing the number of group discussion participants by the group size.	N/A	In percentage	C
(C) Characteristics demonstration field				
Distance road	Distance between demonstration field and a motorable road	What is the distance between the field and a road a vehicle can use?	Amount in kilometres	A,B

Distance home	Distance between demonstration field and the home of the host farmer	What is the distance between the field and your home?	Amount in kilometres	A,B
Distance trading centre	Distance between demonstration field and trading centre	What is the distance between the field and trading centre?	Amount in kilometres	A,B
Distance water	Distance between demonstration field and a water source	What is the distance between the field and a water source?	Amount in kilometres	A,B
Slope	The slope of the demonstration field. In regression, variable is dummy variable taking unity when there is a gentle or steep slope, zero elsewhere.	What is the slope of the demo field?	1. No slope 2. Gentle slope 3. Steep slope	A,B
Non-parallel field orientation	The set-up of the demo field when there is a slope. In regression, variable is dummy variable taking unity when parts are not parallel, zero if parallel.	If there is a slope, what is the field orientation?	1. Parallel: traditional left, CA right 2. Parallel: CA left, traditional right 3. Upper side: CA, lower side: traditional 4. Upper side: traditional, lower side: CA	A,B
Erosion	Whether soil erosion has occurred in the demonstration field. In regression, variable is dummy variable taking unity when there is soil erosion, zero elsewhere	Did you experience soil erosion on the demo field?	1. No 2. Yes	A,B
Soil type	The type of soil of the demonstration field. In regression, variable is a dummy variable taking unity when the soil type is loam, zero elsewhere.	What type of soil is the demo field?	1. Clay 2. Sand 3. Loam 4. Sandy loam 5. Sandy clay 6. Clay loam	A,B
Soil quality	The soil quality in terms of fertility. In regression, the variable is a dummy variable taking unity when the soil is fertile or very fertile, zero elsewhere	What is the quality of soil in terms of fertility?	1. Poor 2. Fertile 3. Very fertile	A,B
Weather shocks	The number of weather shocks in the past three years. In regression, variable is dummy variable taking unity when there is one or more shock(s), zero elsewhere	Have there been weather shocks in the past three years?	If yes, type of weather shock per year	A,B
Pests and diseases	The number of pests and diseases in the past three years. In regression, variable is dummy variable taking unity when there is one or more pests, zero elsewhere	Have there been pests & diseases on the field in the past three years?	If yes, type of pest or disease per year	A,B
Previous crop	Whether maize was previously grown on the demonstration field. In regression, the variable is a dummy variable taking unity when maize was previously grown, zero elsewhere.	What type of crops were grown on the field before it became a demo field?	1. Grass 2. Maize 3. Banana 4. Beans 5. Cabbage 6. Other, specify	A,B
Border field	Whether a border was maintained along the outside borders of the demonstration field. In regression, the	Did you plant a border along the demo field?	1. No 2. Yes, Napier	A,B

	variable is a dummy variable taking unity when there is a border, zero elsewhere.		3. Yes, Tithonia 4. Other, specify	
Border within field	Whether a border was maintained between the CA and conventional part in the demonstration field. In regression, the variable is a dummy variable taking unity when there is a border, zero elsewhere.	Did you plant a border between the CA and conventional part?	1. No 2. Yes, Napier 3. Yes, Tithonia 4. Other, specify	A,B
(D) Characteristics cultivation				
Land preparation method CA	The type of land preparation used on the CA part of the demo field. In regression, the variable is a dummy variable taking unity when zero tillage (slashing and/or mulching) is used, zero elsewhere.	How did you prepare the land for planting on the CA side?	0. None 1. Mulch 2. Slashing and mulch 3. Scratching and mulch 4. Unknown 5. Scratching, slashing and mulching	B,C
Land preparation method TA	The type of land preparation used on the TA part of the demo field. In regression, the variable is a dummy variable taking unity when tillage (ploughing or hoes) is used, zero elsewhere.	How did you prepare the land for planting on the TA side?	0. None 1. Ox ploughing 2. Hoes 3. Slashing 4. Ox ploughing and hoes 5. Ox ploughing and slashing 6. Herbicide spray 7. Slashing and hoes	B,C
Intercrop	Whether the maize on the demonstration field is intercropped with beans. In regression, the variable is a dummy variable taking unity when there was intercropping, zero elsewhere.	Did you plant a crop the 2nd planting season?	N/A	B,C
Weeding method CA	The type of land preparation used on the CA part of the demo field. In regression, the variable is a dummy variable taking unity when hand picking is used, zero elsewhere.	How did you weed on the CA side?	0. None 1. Mulch 2. Mulch and handpicking 3. Mulch and slashing 4. Handpicking	B,C
Weeding method TA	The type of land preparation used on the TA part of the demo field. In regression, the variable is a dummy variable taking unity when tillage (ploughing or hoes) are used, zero elsewhere.	How did you weed on the TA side?	0. None 1. Hoes 2. Ox ploughing 3. Slashing	B,C
Left residue use	The use of residues of the crops after harvest. . In regression, the variable is a dummy variable taking unity when the residue left on the field, zero elsewhere.	Did you leave the crop residue on the field?	0. No 1. Yes 2. Yes, but animals ate it 3. Yes, but people stole it	B,C

Comparison CA and TA				
Labour land preparation	The sum of the amount of hours and people needed for preparing the land of the demonstration field.	How many hours did you prepare the land (per part)? And with how many people did you work?	In amount	B,C
Seed	The amount of maize seeds in kilograms used on the demonstration field (per part)	How many maize seed did you plant?	In amount	B,C
Fertilizer	The amount of planting fertilizer in kilograms used for maize	During planting, how much fertilizer did you use for maize?	In amount	B,C
Date planting	The date of planting. In regression, the variable is a dummy variable taking unity when the date of planting is in April, zero elsewhere.	When did you plant?	N/A	B,C
Spacing	The amount of spacing of the maize rows (within and between the rows) in centimetres. In regression, the variable is a dummy variable taking unity when the spacing is 75x30 cm, zero elsewhere.	What spacing did you use?	N/A	B,C
Labour planting	The sum of the amount of hours and people needed for planting the demonstration field.	How many hours did you use planting the maize (per part)? And with how many people did you work?	In amount	B,C
Labour weeding	The sum of the amount of hours and people needed for weeding the demonstration field.	How many hours did you weed the land (per part)? And with how many people did you work?	In amount	B,C
Organic pesticides	The amount of organic pesticides in kilograms used on the demo field	During spraying, how much organic pesticides did you use?	In amount	B,C
Inorganic pesticides	The amount of inorganic pesticides in kilograms used on the demo field	During spraying, how much inorganic pesticides did you use?	In amount	B,C
Labour pesticides	The sum of the amount of hours and people needed for spraying the demonstration field.	How many hours did you spray the land (per part)? And with how many people did you work?	In amount	B,C
Organic top dressing	The amount of organic top dressing in kilograms used on the demo field	How much organic top dressing did you use?	In amount	B,C
Inorganic top dressing	The amount of inorganic top dressing in kilograms used on the demo field	How much inorganic top dressing did you use?	In amount	B,C

Labour top dressing	The sum of the amount of hours and people needed for top dressing the demonstration field.	How many hours did you top dress the land (per part)? And with how many people did you work?	In amount	B,C
Date harvest	The date of harvesting. In regression, the variable is a dummy variable taking unity when the date of harvest is in October, zero elsewhere.	When did you harvest?	N/A	B,C
Labour harvest	The sum of the amount of hours and people needed for harvesting the demonstration field.	How many hours did you harvest the land (per part)? And with how many people did you work?	In amount	B,C
Maize yield	The amount of maize in kilograms per demonstration field	N/A	In amount	B,C

Table A2: Comparison mean values variables Survey A and Group discussion

Variable	**n**	**Survey A Mean value (SE)**	**Group discussion Mean value (SE)**	**Difference in mean (p value)**
Female	856	0.76	0.75	0.01
		0.03	0.02	0.77
Age	851	41.23	40.22	1.02
		0.78	0.49	0.31
Education (none)	855	0.16	0.14	0.02
		0.03	0.01	0.50
Education (primary)	855	0.40	0.49	-0.09
		0.03	0.02	0.03
Education (secondary)	855	0.37	0.32	0.04
		0.03	0.02	0.26
Education (high)	855	0.08	0.04	0.04
		0.02	0.01	0.02
Christian	855	0.83	0.78	0.05
		0.27	0.02	0.03

Table A3: Benefits and challenges CA

Benefits	**n = 52** **Frequency**
Soil erosion	107
Mulch reduces soil erosion	
Mulch reduces speed of running water	
Mulch reduces force of water	
Mulch reduces direct sunlight	
No direct wind in soil	
Min tillage hard soil which reduces soil erosion	
Roots grow larger and the ground is firmer so better resilient to wind	
Soil fertility	71
Mulch contains soil moisture	
Mulch increases soil organisms (worms)	
Mulch decomposes, adds fertility	
Mulch keeps fertilizer in place (leeching)	
Increase fertility	
Increase soil organisms	
Soft soil	
Soil structure not disorganised by tillage	
Pest management	52
Crop rotation helps to manage pests	
Mulch reduces growth of weeds	
Organic pesticides not harmful for people and animals	
Crop health	46
CA crops higher yields	
Roots plant not disturbed by ploughing	
Crops CA side grow faster and vigorously	
Crops CA side more resilient to wind because wind is firmer because of min tillage	
Mulch reduces impact of wind on crops	
CA crops more tastier	
Production costs	32
Less labour needed (land prep)	
Use of org pest reduce costs	
Manure and org pest long lasting	
Reduce costs because less planting material is needed	
Spacing simplifies work (space to move during harvesting and weeding)	
Challenges	
Animals (rats, snakes, termites, other insects) hide in mulch	34
Collecting and spreading mulch time demanding	28
Scarcity and competition in use mulching materials	20
Due to minimum tillage, soil very hard	12
Buying, collecting and spreading mulch expensive	6
Mulch is sensitive to fire	5
Crops do not grow under mulch (millet, onions)	2
Handpicking harder with mulch	2
Planning needed to prepare organic fertilizers and pesticides	1
Self-made organic pesticides does not control all pests	1

Table A4: Scale of adoption

Motives scale of adoption	n = 52 Frequency
Try out	21
Collecting and spreading mulch demanding in time	19
Scarcity mulching materials	18
Expensive to buy mulch / collect and spread it	11
Scattered land, far from home where mulch needs to brought to	8
Scarcity manure (not much cattle)	7
Competition in use mulching material	2
Expensive to buy manure	2
Did not realize advantages of CA	2
Insecure land ownership: not willing to invest	2
Animals (also from other people) cows, chicken, come to eat mulch or try to find food in the mulch	1
Not all pests controlled with homemade pesticides	1
Time consuming preparing org pesticides and manure	1
Land needed for grazing life stock	1

Table A5: Project participants who do not adopt: motives

Motives not to adopt	n = 524 Proportion
No access to land or just married	21.62
No knowledge: recent member	16.22
No knowledge: not attend training	13.51
Distance land home	9.46
Scarcity mulching materials	8.11
Not seen advantages CA	6.75
Husband did not allow	5.41
Not enough land available	5.41
No knowledge: felt not enough for practice	5.41
Weather shock	5.41
Physical limitations	2.7

Table A6: Adoption – crops

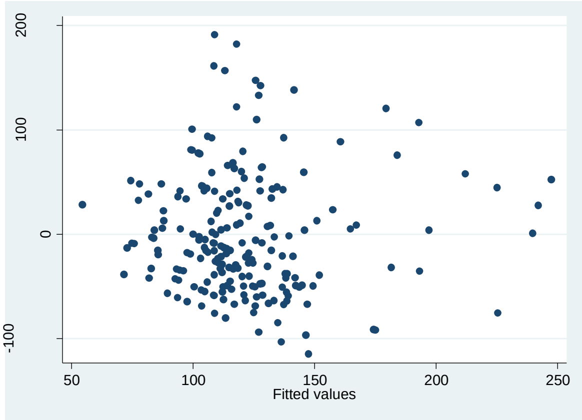
Crops	n = 611 Frequency	Season Category
Maize	309	Short
Banana	236	Long
Beans	156	Short
Coffee	151	Long
Irish potatoes	102	Short
Onions	54	Short
Cabbage	41	Short

Barley	39	Short
Sukuma wiki	32	Short
Wheat	28	Short
G nuts	18	Short
Peas	12	Short
Cassava	3	Long
Sweet potatoes	3	Short
Eggplant	3	Short
Tomatoes	3	Short
Sunflower	3	Short
Apples	1	Long
Grass	1	Short

Table A7: Replication - crops

Crops	**n = 125**
	Frequency
Banana	57
Maize	50
Coffee	31
Irish potatoes	31
Onions	16
Beans	15
Barley	11
Sukuma wiki	11
Wheat	11
Cabbage	9
Peas	5
Eggplant	3
Sweet potatoes	2
Tomatoes	2
Sunflower	2
Apples	1
Carrots	1
Millet	1
G nuts	1

A7: Yield and inputs regression: residuals vs. fitted values



A8: Log transformation yield and inputs regression: residuals vs. fitted values

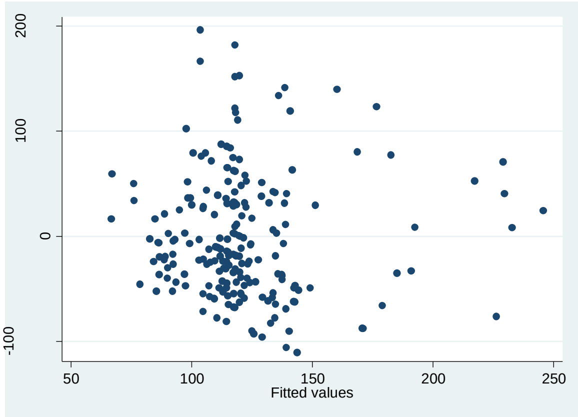


Table A9: Subcounty dummy – Yield and Labour model

Model	**RE (4)**	**RE (5)**	**RE**	**RE**
Dependent variable	**Yield**	**Yield**	**Labour**	**Labour**
CA	30.762***	29.904***	22.822***	22.307***
	(3.969)	(6.414)	(3.131)	(4.393)
Seeds		6.040*		10.084
		(3.303)		(1.660)
Fertilizer		1.736		0.138
		(1.816)		(1.0.774)
Top dressing		-0.293		0.210
		(0.293)		(0.164)
Pesticides		0.015		-0.018
		(0.031)		(0.030)
Labour land preperation		0.458		
		(0.310)		
Labour planting		0.287		
		(0.423)		
Labour weeding		-0.303		
		(0.286)		

Labour pesticides		-0.024		
		(0.397)		
Labour top dressing		1.795		
		(1.395)		
Labour harvest		-0.763		
		(0.553)		
Religion	-0.951	-7.166	12.498**	16.025**
	(10.804)	(17.950)	5.645	(7.341)
Education	10.620	8.096	2.555	0.468
	(8.316)	(8.977)	3.058	(4.359)
Age	1.450	0.958	0.197	-0.007
	(1.042)	(1.545)	0.332	(0.467)
Male / female ratio	23.915	13.805	-11.469	-27.738*
	(31.581)	(40.119)	13.113	(16.193)
Access to land	-7.870*	-9.297	4.295**	5.833
	(4.684)	(10.896)	2.091	(5.031)
Group size	0.588	1.234	0.017	0.122
	(0.637)	(0.971)	0.317	(0.499)
Subcounty 2	-17.384	-36.920	-15.950	-6.716
	(16.822)	(26.812)	12.535	(14.557)
Subcounty 3	-43.780**	-49.180**	6.164	12.547
	(18.506)	(21.703)	9.221	(9.509)
Subcounty 4	16.278	20.795	-2.189	-3.400
	(17.243)	(21.459)	7.791	(9.746)
Subcounty 5	-1.664	-1.264	-7.99	-41.110**
	(20.604)	(40.313)	16.453	(20.016)
Subcounty 6	146.482***	131.334***	-24.237**	-24.097*
	(22.652)	(33.340)	11.621	(12.329)
Subcounty 7	12.367	22.228	-20.677**	-22.303**
	(21.013)	(33.340)	8.039	(10.237)
Subcounty 8	3.522	5.991	-18.527	-14.177
	(26.153)	(30.858)	11.915	(14.813)
Subcounty 9	56.449**	57.659*	-38.789***	-30.592*
	(18.404)	(29.921)	10.876	(18.000)
Subcounty 10	49.974*	26.613	-37.394***	-37.441***
	(29.118)	(27.935)	8.429	(8.867)
Constant	-17.959	-12.711	28.536	45.040
	(56.266)	(68.974)	23.190	(33.793)
Observations	244	146	228	146
R2 within	0.409	0.528500	0.366	0.315
R2 between	0.556	0.642	0.282	0.293
R2 overall	0.537	0.625	0.313	0.301

* p < 0,10, ** p < 0,05, *** p < 0,01, The observations differ per model because of missing socio-demographic, group or cultivation data

Table A10: Adoption intensity and subcounty dummy

Dependent variable	Logit ADOPT	Marginal effects ADOPT
Gender	-0,358	0,0013
	(0,229)	
Age	0,023**	-0,0001
	(0,010)	
Education	0,241**	-0,0008
	(0,080)	
Religion	-0,300	0,0011
	(0,344)	
Access to land	0,013	-0,0000
	(0,020)	
Female ratio	0,771	-0,0027
	(1,071)	
Homogeneous religion	-0,101	0,0004
	(0,280)	
Difference yield	0,005	-0,0000
	(0,006)	
Difference labour	-0,010*	0,0000
	(0,006)	
Subcounty 2	-0,955	0,0034
	(0,608)	
Subcounty 3	-0,599	0,0021
	(0,649)	
Subcounty 4	-0,344	0,0012
	(0,828)	
Subcounty 5	-0,845	0,0030
	(0,555)	
Subcounty 6	-0,525	0,0018
	(0,616)	
Subcounty 7	-0,221	0,0008
	(0,605)	
Subcounty 8	-0,801	0,0028
	(0,680)	
Subcounty 9	-1,629**	0,0057
	(0,613)	
Subcounty 10	-1,088*	0,0038
	(0,591)	
Cut-off point 1	-4,355	
	(1,312)	
Cut-off point 2	1,12	
	(1,15)	
Cut-off point 3	3,424	
	(1,127)	
Cut-off point 4	5,854	
	(1,208)	
Observations	454	454

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. A t-test on the cut off points shows that they are significantly different from zero

Appendix B

Instruments for data collection

Table B1: Survey B

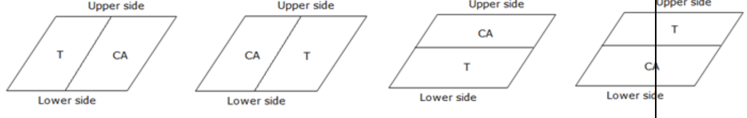
Enumerator		Code	
Date			
District		Code	
Sub county		Code	
Group		Code	
Name of respondent		Code	

EWA Project- Individual host farmer interview notation sheet

Module 1: Socio-demographic characteristics

1. Gender	2. Age	3. Level of education	4. Religion	5. Access to land
1. Male 2. Female		1. None 2. Some primary 3. Completed primary 4. Some O level / Junior 5. Completed O level / Junior 6. Some A Level / Senior 7. Completed A Level / Senior 8. Tertiary Institution 9. University	1. Christian 2. Muslim 3. Other, specify	In acres

Module 2: Characteristics demonstration field

	Question	Possible response (circle appropriate answer)	Explanation / specifications
1	Is the current demo field in the same location as in the first year of the project?	1. Yes 2. No, explain why	
2	What is the distance between the field and a road a vehicle can use?	In kilometres	
3	What is the distance between the field and your home?	In kilometres	
4	What is the distance between the field and trading centre?	In kilometres	
5	What is the distance between the field and a water source?	In kilometres and specify type of water source	
6	What is the slope of the demo field?	1. No slope (continue question 8) 2. Gentle slope(continue question 7) 3. Steep slope (continue question 7)	
7	If there is a slope, what is the field orientation?	Show the farmer and tick the appropriate orientation. Specify why farmer chose this orientation	 Explain why:

8	Did you experience soil erosion on the demo field?	1. No 2. Yes, tick appropriate part	Traditional side Conservation side Upper side Lower side
9	What type of soil is the demo field?	1. Clay 2. Sand 3. Loam 4. Sandy loam 5. Sandy clay 6. Other, specify	
10	What is the quality of the soil in terms of fertility?	1. Poor, specify 2. Fertile, specify 3. Very fertile, specify	
11	Have there been weather shocks in the past three years?	1. No 2. Yes, specify which types in 2012 / 2013 / 2014	2012: 2013: 2014:
	Question	Possible response (circle appropriate answer)	Explanation / specifications
12	Have there been pests& diseases on the field in the past three years?	1. No 2. Yes, specify which types in 2012 / 2013 / 2014	2012: 2013: 2014:
13	What type of crops were grown on the field before it became a demo field?	1. Grass 2. Maize 3. Banana 4. Beans 5. Cabbage 6. Other, specify	
14	Did you plant a border along the demo field?	1. No 2. Yes, Napier 3. Yes, Tithonia 4.Other, specify	
15	Did you plant a border between the CA and conventional part?	1. No 2. Yes, Napier 3. Yes, Tithonia 4.Other, specify	

Module 3: Cultivation demonstration field in 2014

	Traditional agriculture part of demo field		**Conservation agriculture** part of demo field	
Land preparation				
	0. None 1. Ox ploughing 2. Hoes 3. Slashing 4. Ox ploughing and hoes 5. Ox ploughing and slashing 6. Spraying 7. Slashing and hoes 8. Other, specify	Number of times	0. None 1. Mulch 2. Slashing and mulch 3. Scratching and mulch 4. Unknown 5. Other, specify	Type of mulch used 1. Grass 2. Tithonia 3. Bean residues 4. Banana fibre 5. Banana leaves 6. Slashed weeds 7. Maize stalks 8. Barley straw 9. Wheat straw 10. Other, specify
Working hours				
Working people				
Cost of work				
Planting 1st season				
Crop	1. Maize 2. Maize and beans		1. Maize 2. Maize and beans	
Variety code	614 629 Other, specify:		614 629 Other, specify:	

Amount of seed in kg		
Date	Month: Begin / Mid / End	Month: Begin / Mid / End
Spacing in cm	Between lines Within lines	Between lines Within lines
Fertilizer	0. None 1. DAP 2. CAN 3. Other, specify Amount of fertilizer in kg:	0. None 1. DAP 2. CAN 3. Other, specify Amount of fertilizer in kg:
Working hours		
Working people		
Weeding 1st season		
	0. None 1. Hoes 3. Slashing 4. Other, specify Number of times	0. None 1. Mulch 2. Mulch and handpicking 3. Mulch and slashing 4. Other, specify Type of mulch used 1. Grass 2. Tithonia 3. Bean residues 4. Banana fibre 5. Banana leaves 6. Slashed weeds 7. Maize stocks 8. Barley husks 9. Wheat husks 10. Other, specify
Working hours		
Working people		
Pest control 1st season		
Method	0. None 1. Organic mix 2. Inorganic mix 3. Other, specify Amount in litre:	0. None 1. Organic mix 2. Inorganic mix 3. Other, specify Amount in litre:
Working hours		
Working people		
Top dressing 1st season		
Type	0. None 1. CAN 2. UREA 3. NPK 4. Other, specify Amount in kg:	0. None 1. CAN 2. UREA 3. NPK 4. Other, specify Amount in kg:
Working hours		
Working people		
Harvest 1st season		
Date	Month: Begin / Mid / End	Month: Begin / Mid / End
Working hours		
Working people		
Use of residue		0. No 1. Yes 2. Yes, but animals ate it 3. Yes, but people stole it 4. Other, specify

	Traditional agriculture part of demo field	**Conservation agriculture** part of demo field
Planting 2nd season		
Crop	1. Beans 2. Cabbage 3. Other, specify	1. Beans 2. Cabbage 3. Other, specify

	4. None, specify why		4. None, specify why	
Variety code	K132 Other, specify		K132 Other, specify	
Amount of seed in kg				
Date	Month:	Begin / Mid / End	Month:	Begin / Mid / End
Spacing in cm	Between lines Within lines		Between lines Within lines	
Fertilizer	0. None 1. DAP 2. CAN 3. TSP 4. Other, specify	Amount of fertilizer in kg:	0. None 1. DAP 2. CAN 3. TSP 4. Other, specify	Amount of fertilizer in kg:
Working hours				
Working people				
Weeding 2nd season				
	0. None 1. Hoes 2. Slashing 3. Other, specify	Number of times	0. None 1. Mulch 2. Mulch and handpicking 3. Mulch and slashing 4. Other, specify	Type of mulch used 1. Grass 2. Tithonia 3. Bean residues 4. Banana fibre 5. Banana leaves 6. Slashed weeds 7. Maize stocks 8. Barley husks 9. Wheat husks 10. Other, specify
Working hours				
Working people				
Pest control 2nd season				
Method	0. None 1. Organic mix 2. Inorganic mix 3. Other, specify	Amount in litre:	0. None 1. Organic mix 2. Inorganic mix 3. Other, specify	Amount in litre:
Working hours				
Working people				
Top dressing 2nd season				
Type	0. None 1. CAN 2. UREA 3. NPK 4. Other, specify	Amount in kg:	0. None 1. CAN 2. UREA 3. NPK 4. Other, specify	Amount in kg:
Working hours				
Working people				
Harvest 2nd season				
Date	Month:	Begin / Mid / End	Month:	Begin / Mid / End
Working hours				
Working people				
Use of residue			0. No 1. Yes 2. Yes, but animals ate it 3. Yes, but people stole it 4. Other, specify	
Yield in kg				

Module 4: Market prices

	Question	Possible response (circle appropriate answer)	Explanation / specifications
1	Did you sell the harvest of the 1st season crop of the demo field?	0. No 1. Yes 2. Yes, freshly sold 3. No, divided among members	
2	Did you sell the harvest of the 2nd season crop of the demo field?	0. No 1. Yes 2. Yes, freshly sold 3. No, divided among members	
3	If you would buy the fertilizer used in the demo field, how much would you pay for it?		1st season fertilizer: 2nd season fertilizer:
4	If you would buy the top dressing used in the demo field, how much would you pay for it?		
5	If you would have used pesticide on the demo filed, how much would you pay for it?	Price for whole demo field	
6	What is the local katala rate?		Price Measurement
7	How many katala's is the whole demo field?		

Table B2: Individual survey A

Enumerator		Code	
Date			
District		Code	
Sub county		Code	
Group		Code	
Name of respondent		Code	
Host farmer	Yes / No (circle appropriate answer)		

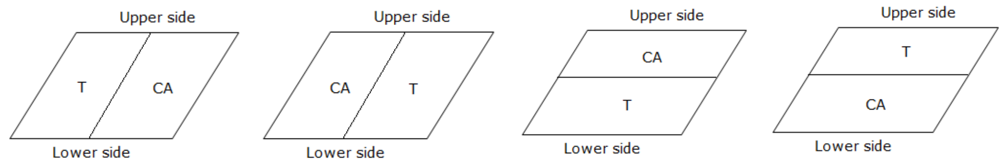
EWA Project- Individual interview notation sheet

Module 1: Socio-demographic characteristics

1. Gender	2. Age	3. Level of education	4. Marital status	5. No. of adults in household	6. No. of children in household	7. Religion	8. Income
1. Male 2. Female		1. None 2. Some primary 3. Completed primary 4. Some O level / Junior 5. Completed O level / Junior 6. Some A level / Senior 7. Completed A level / Senior. 8. Tertiary Institution 9. University	1. Single 2. Relationship 3. Married monogamy 4. Married polygamy 5. Divorce / separated 6. Widow		< 18 years	1. Christian 2. Muslim 3. Other, specify	1. Farming crop, specify 2. Farming life stock, specify 3. Salary, specify 4. Shop keeping, specify 5. Buying & selling of produce, specify 6. Sell of casual labour, specify 7. Tailoring, specify 8. Remittances, specify 9. Other, specify

Module 2: Characteristics demonstration field (host farmer only!)

	Question	Possible response (circle appropriate answer)	Explanation / specifications
1	Is the current demo field in the same location as in the first year of the project?	1. Yes 2. No, explain why	
2	What is the distance between the field and a road a vehicle can use?	In kilometres	

	Question	Possible response (circle appropriate answer)	Explanation / specifications
3	What is the distance between the field and your home?	In kilometres	
4	What is the distance between the field and trading centre?	In kilometres	
5	What is the distance between the field and a water source?	In kilometres and specify type of water source	
6	What is the slope of the demo field?	1. No slope (continue question 8) 2. Gentle slope(continue question 7) 3. Steep slope (continue question 7)	
7	If there is a slope, what is the field orientation?	Show the farmer and circle right orientation. Specify why farmer chose this orientation	 Explain why:
8	Did you experience soil erosion on the demo field?	1. No 2. Yes, tick appropriate part	Traditional side Conservation side Upper side Lower side
9	What type of soil is the demo field?	1. Clay 2. Sand 3. Loam 4. Sandy loam 5. Sandy clay 6. Other, specify	
10	What is the quality of the soil in terms of fertility?	1. Poor, specify 2. Fertile, specify 3. Very fertile, specify	
11	Have there been weather shocks in the past three years?	1. No 2. Yes, specify which weather shocks in 2012 / 2013 / 2014	2012: 2013: 2014:
12	Have there been pests& diseases on the field in the past three years?	1. No 2. Yes, specify which types in 2012 / 2013 / 2014	2012: 2013: 2014:
13	What type of crops were grown on the field before it became a demo field?	1. Grass 2. Maize3. Banana 4. Beans 5. Cabbage 6. Other, specify	
14	Did you plant a border along the demo field?	1. No 2. Yes, Napier 3. Yes, Tithonia 4.Other, specify	

	Question	Possible response (circle the answer)	Explanation / specifications
15	Did you plant a border between the CA and conventional part?	1. No 2. Yes, Napier 3. Yes, Tithonia 4.Other, specify	

Module 3: Empowerment

	Question	Possible response (circle appropriate answer)	Explanation / specifications
1	Do you have access to land for farming?	1. No 2. Yes, renting 3. Yes, own land 4. Yes, husband property 5. Yes, relative property	
2	Did your income increase since the beginning of the project?	1. No 2. Yes, specify. Estimate income before project and estimate current income. <u>Do not include money from relatives!</u>	Income before project: Current income:
3	Did your knowledge on farming increase since the beginning of the project?	1. No 2. Yes, give specific example	
4	Did your participation in the community or local activities change since the beginning of the project?	1. No 2. Yes, give example within the farmer group and example outside the group	In farmer group: Outside farmer group:
5	Do you feel a change in the recognition and respect you receive from your relatives / neighbours / others as a result of participating in the project?	1. No 2. Yes, give example	

<table>
<tr><th></th><th>Question</th><th>Possible response (circle appropriate answer)</th><th>Explanation / specifications</th></tr>
<tr><td>6</td><td>Do you feel a change in your confidence since the beginning of the project?</td><td>1. No
2. Yes, give example</td><td></td></tr>
<tr><td>7</td><td>Since the beginning of the project, are you part of the savings activities in your group?</td><td>1. No, specify why
2. Yes, estimate saved amount so far</td><td>Saved amount:</td></tr>
<tr><td>8</td><td>Since the beginning of the project, have you borrowed money from your group?</td><td>1. No
2. Yes, specify borrowed amount and what the money is used for:
A. Inputs B. School fees C. Start business
D. Expand business E. Livestock F. Hire Land G. Other, specify</td><td><table><tr><th>Amount borrowed</th><th>Used for</th></tr><tr><td>1.</td><td></td></tr><tr><td>2.</td><td></td></tr><tr><td>3.</td><td></td></tr><tr><td>4.</td><td></td></tr><tr><td>5.</td><td></td></tr><tr><td>6.</td><td></td></tr></table></td></tr>
<tr><td>9</td><td>Have you received training(s) about gender issues / empowerment during the project?</td><td>1. No
2. Yes</td><td></td></tr>
<tr><td>10</td><td>Can you give example(s) of differences between the position of men and women with regard to empowerment?</td><td>1. No
2. Yes, give examples</td><td></td></tr>
</table>

Table B3: Group discussion

District		Code		Date	
Sub county		Code			
Group		Code			

Group discussion notation sheet

Individual information

#	Name group member	Sex	Age	Level of education	Religion	Access land	CA	Principles used	Type of crops	Amount land	Inputs AT
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											
	✓ CBF & Host farmer Chair person	0. M 1. F		1. None 2. Some primary 3. Completed primary 4. Some O level 5. Completed Some O level 6. Some A level 7. Completed A level 8. University	1. Christian 2. Muslim 3. Other, specify		0. N 1. Y	1. Mulching 2. Soil cover 3. Organic pesticides 4. Organic manure 5. Minimum tillage 6. Crop rotation 7. Kitchen garden 8. Digging trenches 9. Planting Napier grass 10. Organic fertilizer	1. Maize 10 Cassava 2. Banana 11 Eggplant 3. Coffee 12 Beans 4. Cabbage 13 Peas 5. Sukuma 14 Wheat 6. Onions 15 Barley 7. Sweet pot 16 Grass 8. Irish pot 17 Apples 9 G nuts 18 Tomatoes		0. No 1. Yes

Difference land acceptance CA and total access to land

Module 1: Cultivation demonstration field

	Land preparation				**Planting**								
	Method		Hour	People		Plant	Plant code	Date	Betw	With	Fert	Hours	People
T	0. None 1. Ox ploughing 2. Hoes 3. Slashing 4. Ox ploughing and hoes 5. Ox ploughing and slashing 6. Herbicide spray 7. Slashing and hoes	Repetition:				1. Maize 2. Maize and beans	614 629				0. None 1. DAP 2. CAN Amount		
CA	0. None 1. Mulch 2. Slashing and mulch 3. Scratching and mulch 4. Unknown	1. Grass 2. Tithonia 3. Bean residues 4. Banana fiber 5. Banana leaves 6. Slashed weeds 7. Maize stocks 8. Barley stocks 9. Wheat husks									0. None 1. DAP 2. CAN Amount		

	Weeding				**Pest**			**Topping**			**Plant tea**	**Harvest**		
	Method	Type	Hour	People	Method	Hour	People	Type	Hour	People		Date	Hour	People
T	0. None 1. Hoes 2. Ox ploughing 3. Slashing				0. None 1. Organic mix 2. Inorganic mix Amount			0. None 1. CAN 2. UREA 3. NPK Amount						
CA	0. None 1. Mulch 2. Mulch and handpicking 3. Mulch and slashing	1. Grass 2. Tithonia 3. Bean residues 4. Banana fiber 5. Banana leaves 6. Slashed weeds 7. Maize stocks 8. Barley stocks 9. Wheat husks			0. None 1. Organic mix 2. Inorganic mix Amount			0. None 1. CAN 2. UREA 3. NPK Amount				Left residue? 0. No 1. Yes 2. Yes, but animals ate it 3. Yes, but people stole it		

	Planting (2)								**Weeding**			
		Plant code	Date	Betw	With	Fert	Hours	People	Method	Type	Hour	People
T	1. Beans 2. Cabbage	K132				0. None 1. DAP 2. CAN 3. TSP Amount			0. None 1. Hoes 2. Ox ploughing 3. Slashing 4. Unknown 5. Handpicking Repetition:			
CA	0. None 1. Mulch 2. Slashing and mulch 3. Scratching and mulch 4. Unknown	1. Grass 2. Tithonia 3. Bean residues 4. Banana fiber 5. Banana leaves 6. Slashed weeds 7. Maize stocks 8. Barley stocks 9. Wheat husks							0. None 1. Mulch 2. Mulch and handpicking 3. Mulch and slashing 4. Handpicking	1. Grass 2. Tithonia 3. Bean residues 4. Banana fiber 5. Banana leaves 6. Slashed weeds 7. Maize stocks 8. Barley stocks 9. Wheat husks		

	Pest			**Topping**			**Plant tea**	**Harvest**			
	Method	Hour	People	Type	Hour	People		Date	Hour	People	Kgs
T	0. None 1. Organic mix 2. Inorganic mix Amount			0. None 1. CAN 2. UREA 3. NPK Amount							
CA	0. None 1. Organic mix 2. Inorganic mix Amount			0. None 1. CAN 2. UREA 3. NPK Amount				Left residue? 0. No 1. Yes 2. Yes, but animals ate it 3. Yes, but people stole it			

Module 2: Market prices

No	Question	Answer
2.1	Harvest sold	Harvest 1: 0. No / 1. Yes Harvest 2: 0. No / 1. Yes
2.2	Price fertilizer / top dressing	Fertilizer Top dressing
2.3	Price seeds	Harvest 1: Harvest 2:
2.4	Price pesticide	
2.5	Price katala	Per x Demo field: katala's
2.6	Price oxen ploughing	

Acceptance group members not present and replication of non-project participants

#	Name	Sex	Adoption	Principles used	Type of crops	Input AT
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
		0. M 1. F	1. Acceptance 2. Replication	1. Mulching 7 Kitchen garden 2. Soil cover 8 Digging trenches 3. Organic pesticides 9 Planting Napier grass 4. Organic manure 10 Organic fertilizer 5. Minimum tillage 6. Crop rotation	1. Maize 7. Sweet pot 13. Peas 2. Banana 8. Irish pot 14. Wheat 3. Coffee 9. G nuts 15. Barley 4. Cabbage 10. Cassava 16. Grass 5. Sukuma 11. Eggplant 17. Apples 6. Onions 12. Beans 18. Tomatoes	0. No 1. Yes