Evaluating Impacts and Analyzing factors determining food security and technology Innovation of the Agricultural Skills for You (AS4Y) project in West Nile sub-region, Uganda

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ACRONYMS AND ABBREVIATIONS

AS4Y	Agricultural Skills for You
FS	Food Security Ratio
FSS	Food Self-sufficiency
TLU	Total Livestock Units
GAP	Good Agronomic Practice
IPM	Integrated Pest Adaption
VOP	Value of Production
FAO	Food and Agriculture Organization of United Nations
ZOA	Zuid-Oost Azië an international relief and recovery organization
WFP	United Nations Word Food Programme
CEFORD	Community Empowerment for Rural Development
IITA	International Institute of Tropical Agriculture
USAID	U.S. Agency for International Development

Abstract

In light of the growing concern of the low agricultural production problem in the West Nile sub-region of Uganda, a package of agricultural skills has been promoted through the Agricultural Skills for You(AS4Y) project which was introduced and executed by ZOA since 2003. This study is based on ZOA's end-line and baseline survey data in 2016 and 2013 respectively. Based on the survey data this study aims to evaluate the impact of the AS4Y project on food security (FS) and identify the factors that affected the progress of FS ratio and technology adaptation. We found that the project had a negative impact on food security ~~household improved the food self-sufficiency (FSS)~~ ratio. ~~significantly after AS4Y project's intervention.~~ Farmer's strategy of increasing crop diversity improved their ~~FS ratio and~~ FSS ratio significantly. The gender of household head was a significant factor of FS and FSS ratios and technology adaptation. The probability of becoming an innovator is significantly affected by the project's intervention, farm size, the strategy of changing crop patterns~~initial food security ratio~~, and the gender of household head. ~~Moreover, the strategy of decreasing the crop number fostered technology adaptation.~~ The results are important for ZOA to tailor future interventions and help farmers to achieve a higher level of food security and food self-sufficiency.

Key words: impact evaluation, food security ratio, technology adaptation, cropping strategies, attitude

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1. Introduction

1.1 Food Security in Uganda

The Food and Agriculture Organization of the United Nations (FAO) defined food security as: “all people at all time have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life” (FAO,2002). Findings from the comprehensive food security and vulnerability analysis (WFP,2013) showed that around 48% of households in Uganda were suffering from food insecurity, especially in the north of Uganda which is the most food insecure region. The progress of reducing poverty in the rural area is enormous with decrease from 24.5% in 2009/2010 to 19.7% in 2012/2013 (UNDP,2014). Despite the national progress on rural poverty eradication, food insecurity is still high due to the strong population growth of 3.22% annually (CIA, 2016), the absolute number of poor people increased.

Uganda has high agricultural potential as it is equipped with fertile soils and abundant water resource (e.g. rivers, lakes and regular rainfall). The agriculture sector is the backbone of Uganda which contributes 85% of export earnings and 75% of national employment(USAID,2015). Agriculture is dominated by mixed crop-livestock smallholders farming systems producing for home consumption and market (Okoth *et al*.,2002). Farmers grow a high variety of crops such as cassava, sweet potatoes, maize, millet, Irish potatoes and peanut (Wikipedia, 2016). Agricultural improvements are necessary to increase the economic performance and reduce poverty in Uganda. The Agricultural Skills For You (AS4Y) project was introduced to help farmers to overcome farming constraints locally by providing a technology package and training program.

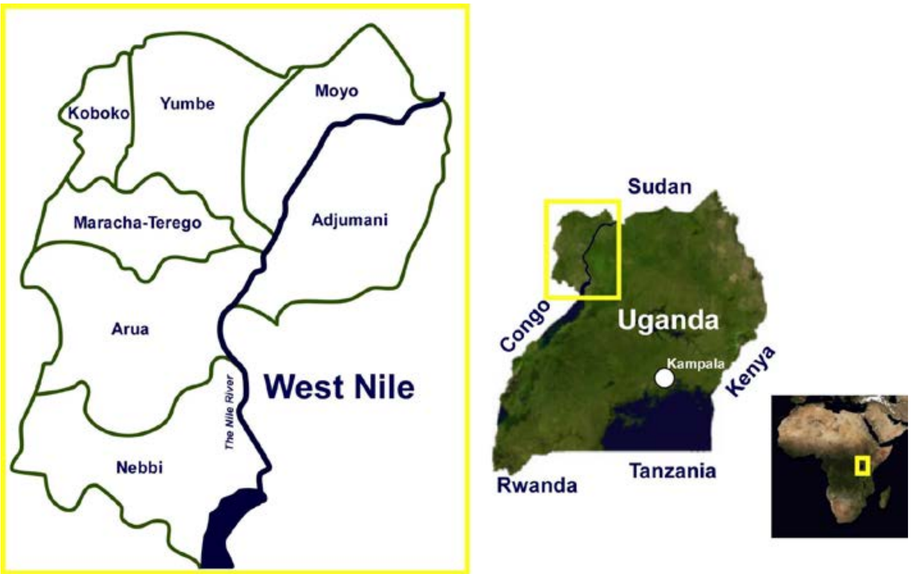
1.2 Project Background

The AS4Y project was carried out in the West Nile sub-region which is located in the Northern part of Uganda, bordering with South Sudan and the Democratic Republic of the Congo (see Figure 1). The AS4Y project was executed by ZOA (a Dutch NGO) since 2013. The project was implemented in the districts of Arua, Koboko, Moyo, Nebbi and Zombo. The main agricultural problem in the West Nile sub-region is the low agricultural productivity leading to regional food insecurity (CEFORD, 2016). The declining soil fertility, pests and diseases, land fragmentation, poor farming methods, poor planting materials, inadequate extension services, unpredictable weather conditions, HIV/AIDS pandemic and inaccessibility to financial services are the underlying cause the low productivity. The AS4Y project was set up to address these challenges with the overall goal of increasing incomes and improving food security for rural households in the West Nile sub-region of Uganda. Through market-driven vocational and agro-business trainings, farmers can better access the (labor) market in Northern Uganda. Also, many agricultural technologies were introduced to the farmers through the AS4Y project. The list of proposed technologies and identified constraints from the baseline survey are reported in the Appendix.

The interventions that farmers were trained in are shown in Appendix 3. The modified technologies include: Good Agronomic Practices(GAP), Integrated Pest Adaptation(IPM), Climate Change Adaptation (also called Climate Smart Agriculture), soil conservation and fertility management.

The International Institute of Tropical Agriculture(IITA) acted as a partner for this project. As a research organization it performed a livelihood and production assessment, organized a feedback to farmers and stakeholders on their findings and has been involved in field trials. Currently IITA is evaluating the effectiveness of the various interventions regarding skills adoption and innovation through an end-line survey. Our study is part of the IITA evaluation**.**

Figure 1~~1~~ Location of West Nile sub-region (Nile Care(2016))



1.3 Literature Review

This section shows the literature review for the explanatory variables and the hypothesis on how these variables influence the progress of FS ratio and technology adaptation. The choice of explanatory variables to estimate the progress of food security ratio and technology innovation is based on the available data and literature review. The descriptions of the explanatory variables used in our analysis are presented in Table 1.

Luan, Cui and Ferrat (2013) indicated that the self-sufficiency reflects the ability of a country or region to feed its population. Self-sufficiency depends on on-farm production and consumption(FAO,2001). A baseline report of the AS4Y project from Kansiime (2015) calculates food self-sufficiency using the household's food energy available from farm production and the household's food requirement in one year. In this study, we calculated food self-sufficiency and compared it with baseline data to determine the households' ability to sustain their family. The method of calculating food self-sufficiency is presented in section 2.3.1. We expect an increase in food self-sufficiency ratio after project's interventions.

The food security in this study was measured by the food security ratio which is the ratio between household's food energy available from both on-farm production and purchased and food energy requirement in one entire year. The specific methods to calculate FS ratio is presented in section 2.3.2 of this report. Here are they reasons why food security matters a lot. Research on food security is important due to several reasons as given by Jones *et al.*, (2013). Firstly, food security is a vital topic for policy makers and academics around the world as it relates to human rights and matters in almost every aspect of society. Secondly, meeting people's calories requirement is the essential condition of public physical and mental health, so food security estimations for current and future are key drivers for the policy making and facilitation of making decision by the government that affect public health. Finally, national food security affects maximizing financial capacity as well because a nourished population guarantees economic productivity. We expect an increase of FS ratio on household level after various trainings provided by AS4Y project.

Technology adoption is an individual mental process and limited by external factors such as household characteristics, farming systems features, resource access, properties of the technology, farmers access to social networks (Perz, 2003) and the risk attitude of farmers (Kebede, 1990). Similarly, the decision of whether to modify the technology is based on the evaluation of technical, economic and social factors by farmers. The AS4Y project promoted a package of agricultural technologies (Appendix 3). The goal of the package was to make better use of agricultural resources to improve the farms' performance with the final indicator of an increased food security ratio. The project expect the farmers have the ability to modify a technology they have been trained in, to make it more suitable to their situation. The process of modifying a technology is called technology adaptation in this study. The questions of technology adaptation and impacts in the end-line survey can be found in the Appendix 6, section 7.4. We hypothesize that technology adaptation has a positive correlation with increases in terms of a household's food security ratio.

Financial characteristic is a major factor that influences technology adoption and adaptation. It is assumed that the adoption and adaptation of any technology requires sufficient financial support (Lynne et al., 1995). Many analyses used income, gross income and farm profitability as the indicator to correlate with technology adoption and adaptation. A majority of the analyses indicate a positive relationship between farm financial status and technology adoption (e.g. Somda et al.,2002; Franzel, 1999). A study in Nepal (Karki et al.,2004) finds that food security has a positive but not significant impact on technology adoption. Food security ratio can reflect the household financial status. So this study uses primary economic status, in the form of FS ratio, as an indicator to explain the possibility of technology adaptation. This study hypothesizes that a higher initial food security status increases the possibility of technology adaptation.

Scientist paid attention to a variety of biophysical characteristics of the farm itself when assessing the adoption or adaptation of technology. One common factor is farm size. It is often hypothesized that a farmer with a larger land size is more willing to try new technologies (Knowler, 2007) as farm size is associated with greater wealth(Deressa et al., 2009) and hence greater room to maneuver. However, there is no consistent conclusion on the impact of farm size on technology adoption (Knowler & Bradshaw, 2007). Farm size is observed as a positive indicator for the adoption of conservation tillage in the United States (Fuglie, 1999). Other studies, however, found that farm size has a negative correlation with technology adoption. For example, farmers in Kenya with a small farm size are more likely to adopt soil conservation practices (Nyangena,2007). For the technology adaptation, literature found that farm size positively correlates with the adaptation to climate change (Deressa et al., 2009). This study assumes that a household with a larger farm size is more likely to adapt the technology. In addition, hunger is also related to farm size as a great proportion of poor people living in rural area, and they have limited or no access to arable land with high productivity (Tscharntke et al., 2012). We hypothesized that for smallholders increasing the arable land improves the food security ratio.

The literature shows that the influence of family size on the technology adoption and adaptation is inconclusive although a large household size can do the labor intensive adaptation technologies. Family size has a positive impact on the fertilizer adoption in the study area, but it has a mixed effect on single-ox and pesticides adoption (Kebede, 1990). Smaller family sizes tend to adapt monocropping, while large households have high possibility to adapt multiple cropping (Hassan & Nhemachena, 2008). This study hypothesizes that a large family size improves the probability of technology adaptation.

As opposed to the positive correlation between family size and technology adaptation, family size is negatively correlated with FS ratio. The assumption for the negative relationship between family size and food security ratio is that large families may divert part of the labor to off-farm activities to earn incomes and release the pressure of farm consumption (Tizale, 2007). Considering the rare chances of off-farm activities for most smallholders, the pressure of on-farm production cannot be released. Moreover, the demographic expansion leads a greater demand in food production but the supply is not increasing enough (Luan et al., 2013). Thus, we expect a negative correlation between household size and FS ratio.

Shifting the view to intra-household differences, Asfaw and Admassie(2004) argued that male-headed households have a higher probability of receiving the information about new technologies than female-headed households. Due to traditional social barriers, female-headed households have barriers to access information, land and other resources hampering technology adoption (Tenge et al., 2004). However, female-head households showed a higher possibility to adopt climate change adaptation measures than the male-headed household according to Nhemachena and Hassan (2007). The research however did not find that gender factors influence the possibility to adapt irrigation, multiple cropping and mixed systems (Hassan & Nhemachena, 2008). In the AS4Y project, gender awareness and mainstreaming have been introduced in every district (Appendix 4). So we expect that female-headed families in the treatment group improved FS ratio in the end-line survey year.

In Nwoya District, Uganda which is near the West Nile region, a similar project was conducted by ZOA. Riley (2016) found that the strategic selection of crops improved the value of production(VOP). Reducing the number of crops grown and the area cultivated had negative effects on VOP and other progress indicators. Based on the findings from Nwoya project, in this study, we put a suite of variables to the multiple regression analysis models to test which variable closely correlated with improved FS ratio and the technology innovation. These variables are: number of crops started planting, the number of crops stopped farming, the number of crop with less land area, and the number of crop with more land area, all compared to the baseline situation. We also expect that the strategy of selection of crops and changing the cultivated crop area have a positive impact on the progress of FS ratio and technology adaptation.

In history, the research of agricultural technology diffusion and adoption has regarded farmer's decision making as voluntarism (Lynne et al., 1995). Melissa (2012) indicated that farmers' attitudes do have impacts on technology adoption. Melissa (2012)'s study used a screener tool to classify farmers into segments by asking six statements. The six statements are: "proud to be a farmer", "farming is the best investment", "I would not be a full-time farmer, if I had choice"," I'd like to pay for the farm method that saves time", "no hope for farmers", "hope next generation do not end up working as farmers".

Religion as a part of the culture is considered to have a significant impact on people's lifestyle which influences the decision making(Delener,1994). One of the functions of religion is to give people a framework which can make life comprehensible and explicable (Petersen & Roy, 1985). In West Nile region most farmers have religion, and Christian occupies a large proportion of 80% (Wikipedia, 2016). Thus, apart from the six attitudes mentioned by Melissa (2012), this study takes the perspective of religion into account. It is hypothesized that a higher level of supporting the view "God meant me to become a farmer" is associated with a greater possibility of technology adaptation. Here we have seven statements to evaluate farmer's attitude in total (Table 1).

Based on the perceptions of farmer we categorized these statements as optimists, religious, positive, frustrated escapist, and trapped which are presented in Table 2. We expect the optimists and positive farmers are more likely to adapt the technology. It is hypothesized that the farmers' perception influences the farmers' decision making consequently affect the farmers' performance. The trapped farmers and frustrated escapist are assumed to lower the probability of technology adaptation and decrease the progress of FS ratio. On the contrary, we hypothesize that the optimists, religious, positive farmers have higher possibility to adapt the trained technologies and improve the FS ratio.

An important resource of agronomic information is from the extension service (Hassan & Nhemachena, 2008). So it is hypothesized that the AS4Y project intervention improves the food security ratio for the household. The available information on crop and livestock production is reported to have a strong relationship with the farmers' adoption behavior(Tizale,2007). However, other adoption studies have found that extension education is not a significant factor affecting the conservation practice adoption(Birungi,2007). A positive relationship was found between better access to extension education and adaptation measures by Hassan and Nhemachena, (2008). Thus, for this study, the project participation is hypothesized to increase the possibility of technology adaptation.

The baseline report of AS4Y project indicated that total livestock units negatively associated with the crop productivity and the impacts of TLU on VOP was not significant (Kansiime, 2015). Considering that the total livestock unit often presents the wealth of household. So in the end-line survey we expect a positive relationship between Total Livestock Units and FS ratio or FSS ratio. TLU may also positively correlate with technology adaptation.

From Above we summarize the chosen variables in table1.

Table 1 Description of the e variables for technology adaptation and the progress of FS ratio analysis

Variable	Definition
HH size	Household size: Number of household members .
FarmSize	Farm size: Area cultivated by household in survey year(acre)
stopCrop_num	Number of crops stopped planting in the survey year
startCrop_num	Number of crops started planting in the survey year
cropMoreArea_num	Number of crops increased plant area in the survey year
cropLessArea_num	Number of crops reduced plant area in the survey year
UseTech	Technology innovation: farmers changed the technologies they were trained
att_optimistic	Optimistic: proud to be a farmer.
att_religious	Religious: God meant me to become a farmer.
att_positive	Positive: the average score of "farming is the best investment" and "I'd like to pay for the farm method that saves time"
att_escape	Frustrated escapist: the average score of "I would not be a full-time farmer if I had choice" and "hope next generation does not end up working as farmers"
att_trapped	Trapped: no hope for farmers.
FSratio_base	Food security ratio in the base line survey year
Project	The participation of AS4Y project
HH_gender	Gender of household head
TLU	Total livestock units

Table 2 The five segments based on the attitudes of statements in the survey

Segment	Description
Optimists	• Shows a very positive attitude to farming and proud to be a farmer
Religion related	• Believes God meant he/she to become a farmer
Positive	• Thinks farming is the best investment and would like to invest money on farming.
Frustrated escapists	• Treats farming as an alternative choice, if have choice he/she would not be a farmer and hopes nest generation do not end up working as farmers
Trapped	• Thinks no hope for farmers

1.4 Objectives

This study was undertaken as part of the IITA/ZOA project. The primary objective is to evaluate the project intervention on food security. The impact assessment of the project interventions will help ZOA to assess the project progress. At the same time, identifying the factors influencing the gain in food security can bring farmers and the future project significant improvement in the households' performance. The performance of technology adaptation as a part of the project and the analysis of the factors that contribute to the farmer's behavior provide information for the future interventions and research. These motivations led to our study which follows these specific objectives:

1) To assess the impact of the project interventions in terms of food security.
2) To investigate the factors that influence food security.
3) To identify the factors determining the adaptation of technologies /on-farm practices.

And the following research questions need to be addressed:

1) Does the AS4Y project have significant impact on food security ratio?
2) What factors have influence on food security ratio and how do these affect the progress of food security ratio?
3) What indicators influence the progress of technology innovation and how do they change the performance of technology innovation?

1.5 Study Structure

This study includes two parts. The first section of this study is the impact evaluation of the AS4Y project regarding food security ratio and food self-sufficiency ratio. The study examines predictors to explain the variability of the progress in food security. The factors in this analysis include households' characteristics, technology adaptation, the farming decision of changing crops and the cropland allocation, and the attitudes of becoming a farmer.

In the second part, the performance of technology adaptation was assessed. In this study technology adoption was included in the technology adaptation which refers to that farmer modified techniques they learnt from training. The technology adaptation aims to make these technologies more useful for farmers based on their situation. This study explores the relationship between technology adaptation and a suit of explanatory variables. The results will inform the organization and implementation of future research.

2. Methodology

2.1 Literature Study

For the study we did an additional literature search on:

- Definitions of food self-sufficiency and food security, explanatory variables for FS ratio, FSS ratio and technology adaptation.
- The methodologies of impact evaluation.
- The methods of statistic data analysis including multiple regression model and paired sample T-test.

2.2 Data collection

IITA/ZOA conducted the baseline survey and collected household data in 2013. For the research purpose, the end-line survey was carried out in June 2016. The project involved 500 farming households in five districts (Arua, Koboko, Moyo, Nebbi and Zombo) of West Nile sub-region. The study districts were purposively selected as those where ZOA is implementing the AS4Y project. 150 of those 500 households joined the AS4Y project as the treatment group. And the rest is control group without AS4Y project intervention.

2.3 Analytical Framework

Data was analyzed by using Excel and R.

2.3.1 Food self sufficiency

Food self-sufficiency is used to evaluate whether the food produced on the farm is enough for households' consumption according to the energy requirement. In this study, FSS considered all food items produced on the farm. The on-farm production includes both household consumption and sale of products. The revenues of the sold products were converted into food for the household by assuming that the revenues were used to buy maize flour for home consumption. To bring the end line survey results into correspondence with the baseline report, this study used an average price of UGX 1,200 per kg of maize flour (Kansiime,2015). The FSS ratio was calculated by using equation (1)

$$FSSratio_i = \frac{\{\sum_1^p (Qty\, C_p * E_p)\} + \{\frac{VP_{sold} - C_p}{P_m 1200} * E_m\}}{\sum_{j=1}^n K_j} \qquad (1)$$

In the equation (1) Qty is the quantity of food item p produced on farm and directly consumed by households. C_p is the on-farm production cost in UGX for the whole year. E_p is the energy equivalent of food item p, the list of the food energy equivalent used in this study was presented in Appendix. VP_{sold} is the value of produce sold in UGX. E_m is the energy equivalent of maize flour which is 3650kcal/kg in this study. P_m is the price of maize flour in the study year. The average price of maize flour in the baseline and end-line survey years were 1200 UGX/kg and 2150 UGX/kg (*AGMIS*,2016) respectively~~The number "1200" is the average price of maize flour~~. In the study, we assumed all the income from on-farm production was used to buy maize flour. To convert to energy a kg maize flower is multiplied by the energy equivalent of maize flour(E_m). K_j is energy requirement in Kcal per capita for j member in the whole year (365 days), and n is the number of members in household i.

This study assumed adult male and adult female have the same energy requirement with 2500Kcal per day. However, the equivalent for male and female under 18 years old are 0.5 and 0.4 of adult energy needs per day respectively (Kansiime,2015)

When the food self-sufficiency ratio is equal or larger than one it means that the household can satisfy the household's energy requirement by on-farm production for the entire year.

2.3.2 Food Security Ratio

Food Security was calculated by the households' food energy requirements in the whole year against the energy available from on-farm production and off-farm source in the entire year. All off-farm income was assumed to be used to purchase food because the amount of food purchased was not available in the survey. The food security ratio was presented based on the equation (2)

$$FSratio_i = FSSratio_i + \frac{\sum_1^n \left(Y_{off-farm} / P_m \right) * E_m}{\sum_{j=1}^n K_j} \quad \textbf{(2)}$$

where $Y_{off-farm}$ is the income from off-farm sources. P_m is the price of maize flour in the study year. The average price of maize flour in the baseline and end-line survey years were 1200 UGX/kg and 2150 UGX/kg (*AGMIS*, 2016) respectively. ~~The number "1200" represents the average price of maize flour.~~ In the study, we assumed all the off-farm income was used to buy maize flour. To convert to energy a kg maize flower is multiplied by the energy equivalent of maize flour(E_m). $FSSratio_i$ is food self-sufficiency ratio of household i.

When the food security ratio is equal or greater than one it indicates the household achieved fulfilling its food energy needs for the food security for the entire year based on on-farm production and buying food from off-farm income sources.

2.3.3 Farmers' Attitude

This study evaluates the five farmers' perspectives similarly to Melissa (2002). A 5-point scale (from 1 to 5) was used for assessing the attitude, which stands for strongly disagree (1), somewhat disagree (2), neutral (3), somewhat agree (4), strongly agree (5) respectively. For the *optimistic*, *religious* and *trapped* farmers we used the score farmers evaluated. The *positive* holders take the average score of statements "farming is the best investment" and "I'd like to pay for the farm method that saves time". The *frustrated escapist* farmers take the average rating of statements "I would not be a full-time farmer if I had choice" and "hope next generation does not end up working as farmers."

2.3.4 Total Livestock Unit

Livestock unit is a common unit which help to aggregate various livestock species by using specific coefficients as conversion factors of each type of animal. Livestock types and their conversion factors in this study are: local cattle (0.7), improved cattle(cattlelm: 0.7), goats(0.1), sheep(0.1), local chicken(0.01), improved chicken(chickenlm: 0.01), ducks(0.02), layers(0.01), local pigs(0.2), improved pigs(pigslm: 0.2), rabbits(0.001), Oxen (0.7). The source of livestock conversion factors is from HarvestChoice (2016).

2.3.5 Multiple Regression Model

The Multiple Regression Model is used to predict a binary dependent variable (technology adaptation) from hypothesized factors in order to assess the impacts of these factors on technology adaptation progress.

$$\text{Prob}(TECH = 1) = {}^{1}/_{1 + e^{-Y}} \qquad \textbf{(3)}$$

$$\text{Y} = \beta_0 + \sum_{i=1}^{n} \beta_i \chi_i + \mathcal{E}_j \qquad \textbf{(4)}$$

Where TECH is a dichotomous dependent variable (1 if technology adaptation takes place, 0 otherwise), χ_i includes all the vector of variables we test in the model, β_i is the parameters to be estimated, ε_j is error term of the model, and e= base of natural logarithms.

In the study, when the technology adaptation takes place it means that a farmer changed the technologies he or she was trained in to make these technologies more useful for him or her.

Multiple regression analysis was performed to assess which factors are the best predictors to explain the progress in food security. These predictors included in this analysis were: project participation, farm size, household size, start crop number, stop crop number, the number of crop with more land area, the number of crop with less area, household-head gender, food security in the baseline survey, TLU, and the five different attitudes.

2.3.6 Methodological Approach for impact evaluation

Impact evaluation is used to examine whether a target has been achieved.

There are two approaches for impact evaluation：

a. **Before and After Approach**: This approach compares the performance of the same households before attending the project and after being trained by the project.
b. **With and Without Approach**: This approach compares the performance of the farmers participated in the project with the performance of the farmers who are not involved in the project.

The **Before and After Approach** was applied to assess the impacts of AS4Y project interventions in terms of Food Security ratio in the study. We compared the Food Security ratio of households before they get involved in the project in 2013 and the performance after the project intervention in 2016. We used Paired T-test to test the significant difference between the FS ratio before project intervention and after project intervention to see whether the project has positive effects on the farm performance.

The **With and Without Approach** was used as the methodology for investigating the factors that affect technology innovation. Because questions about technology adaptation were not asked in the baseline data, we can not test farmers' performance between before and after intervention.

2.3.7 Paired Sample T-test

Paired sample t-test is applied to the "Before and After" studies to test whether two samples are significantly different from each other. In the study, we collected data from the households before the AS4Y project and after AS4Y project. By using paired sample t-test, we can statistically figure out the impacts of the project's interventions. Following the instruction by Paired Sample T-Test - Statistics Solutions, this analysis established two hypotheses. The Null hypothesis is that the two paired samples' mean are equal, which means there is no effect of the project on food security ratio. The alternative hypothesis is that the two samples' mean is significantly different from each other, which assumes that there is an effect of the project.

We use the formula (4) and (5) to calculate the parameter t.

$$\text{t} = \frac{\overline{X_D}}{SD/\sqrt{n}} \qquad (4)$$

$$\text{SD} = \sqrt{\frac{\sum(X_D - \bar{X}_D)^2}{n-1}} \quad (5)$$

Where t is the paired sample t-test with n-1 degrees of freedom. $\overline{X_D}$ is the mean difference between two samples. SD is the sample variance. n is the sample size. X_D is the individual different scores.

We compared the observed t value with the critical value. If the observed t-value is greater than the critical value, we will accept the alternative assumption. Otherwise, we will accept the null hypothesis which means there is no significant difference between the means of the two paired samples.

3 Results and Discussion

3.1 Descriptive Results

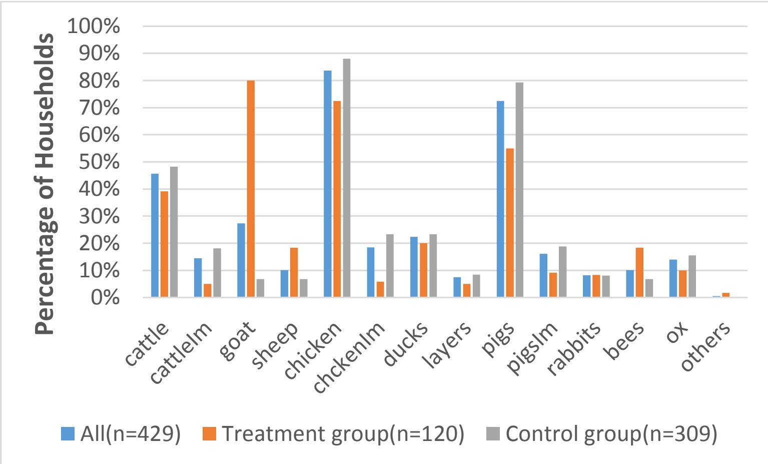
Table 3 summarizes the key characteristics in this study. The household size was seven members per household in the treatment group and eight members per household in the control group which increased in the end-line survey year compared to the family size in the baseline survey. The average farm size of the HH was 2.7 ad 2.4 acres in the treatment and control groups respectively. However, the average farm size in the end-line survey year was decreased by 21.9% and 31% in the treatment group and control group respectively. We used total livestock units (TLU) to aggregate different animal species and numbers for every household. The average TLU of the treatment group decreased slightly from 1.982 to 1.73, whereas the average TLU increased almost 50% in the control group. For all animal species, the proportion of the household keeping animals was larger in the control group than in the treatment group - except goat and sheep (Figure 2).

Table 3 The household's characteristics of West Nile region

		All households (n=41029)	AS4Y group (n =11320)	Control group (n =309)
Av.HH size	**End-line**	8.5627±4.2747	7.6217±3.2664	8.6992±4.6955
	Base-line	6.856.86±2.8182	6.782±2.889	6.9±2.78
	Change(%)	20.724,7	6.712.3	25.9
Av.farm size(acres)	**End-line**	2.51±1.742	2.658±1.85	2.454±1.67
	Base-line	3.51±2.3	3.453±2.4752	3.54±2.23
	Change(%)	-28.4	-21.930.1	-31
Av. TLU	**End-line**	2.196±3.152	1.753±1.912	2.373±3.582
	Base-line	1.6871±2.5	1.982.04±2.452	1.596±2.562
	Change(%)	28.5	-12.614,2	49.3

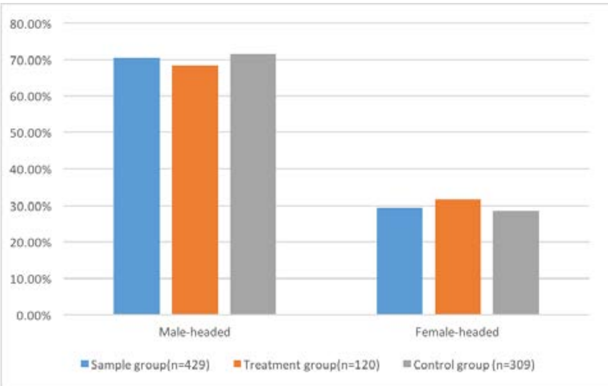
The baseline report indicated(Kansime,2015) that most households depended on crop farming. Livestock contributed little to the household income in the study area. In the end-line survey, the main animals were chicken, pigs and cattle (Figure 2). In the treatment group, a much lower proportion of households had livestock, except for sheep and goat. After checking the baseline data, we found that 68% of farmers participated in project already had goat and 13% of farmers in the treatment group kept sheep in the baseline survey year. The higher proportion of families in the treatment group had goat and sheep is the selection bias. For farmers who choose to raise goat and sheep, they might have access to public rangeland or private grazing land. And an additional labor needed to herd goat and sheep.

Figure 22 The livestock composition in the end-line survey



The proportion of male-headed and female-headed household were approximately equal in the treatment and control group (Figure 3). Around seventy percent of families across the study region are male-headed, and about thirty percent of households are female-headed. Even though the female-headed families occupied a small part, they are more likely to improve FS ratio and modify technologies (section 3.4 & section 3.5). This result could be the effort of various programs which target female farmers.

Figure 33 The distribution of the gender of household head in the end-line survey



The proportion of technology adaptation by farmers was relatively small in the treatment group compared to the control group *(Figure 4*). Results from previous and further data showed farmers in the control group had a higher food security and food self-sufficiency status and TLU in the baseline study (Table3 & Section 3.2) which means they were under a good wealth status. So they had capital to take the risk by modifying technologies they have been trained. While for most farmers in the treatment group, it was safety just to apply technologies they learned.

Figure 4~~4~~ The distribution of technology adaptation in the end-line survey

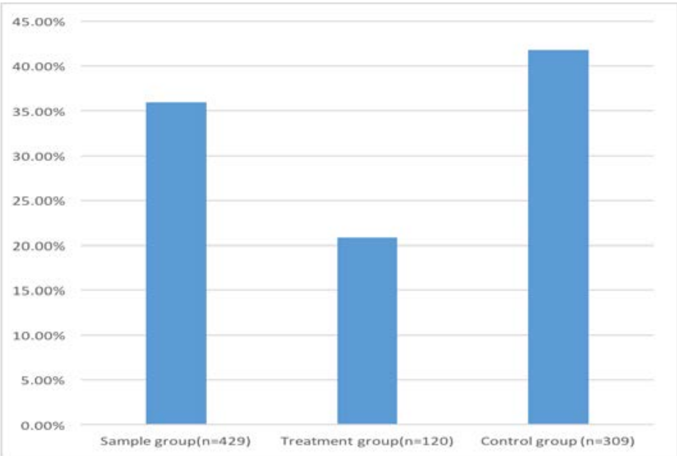


Figure 5a and 5b present the results from asking farmers to choose three important factors why they started or stopped planting a certain number of crops and why they increased or decreased land area. Farmers changed the number of crops cultivated mainly considering the market demand and the crops' productivity. Labor input for a crop was a major factor for a farmer to decided to stop growing a crop. When starting a new plant, they considered the household demand.

Market demand was also a major factor when deciding the crops' planting area. For increasing the crop area, household demand and value of crops were the more often considered reasons. High labor input and low productivity were relatively often mentioned factors explain decreasing the crops' area. The study investigated the influence of changing crop species and crop land on FS and FSS ratios and technology adaptation in section 3.3, 3.4 and 3.5.

Figure 5~~5~~a The reasons of changing crop pattern

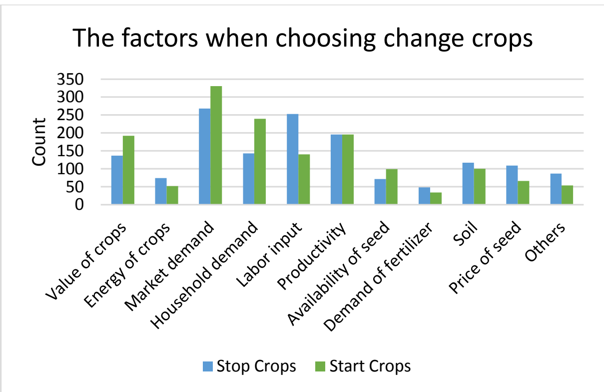
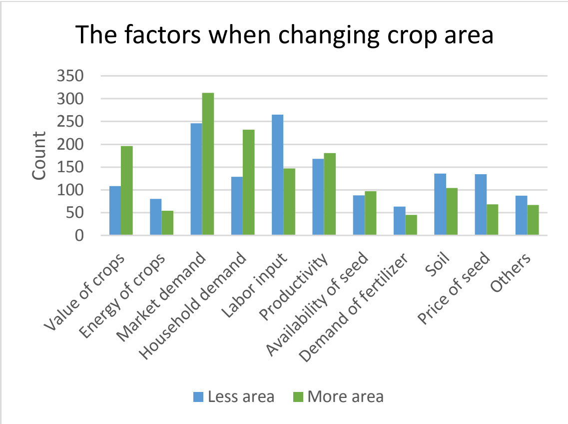


Figure 5b The factors when rearranged the cropland



3.2 Food Security Ratio and Food Self-sufficiency Ratio

Table 4 presents the food security and food self-sufficiency status in the study region. In the end-line survey year, 33.740% of households in the treatment group and 527% of families in the control group achieved food security. For the treatment group, compared to the baseline survey year, the percentage of HH achieved food security reduced from 8079% to 33.740%, and the percent of families fulfilled food self-sufficiency improved from 29.288% to 32.740%. For the control group, the proportion of farmers met food security declined with 3022%, while the percentage of food self-sufficiency HH increased with around 168%. More farmers in both treatment and control groups achieved food self-sufficiency in the end-line survey year, while the proportion of farmers fulfilled food security decreased dramatically. When looking into the average value of FS and FSS ratios from Table 5, we found that the average FSS ratio of control and treatment groups were both improved significantly in the end-line survey which proves the results from Table 4. And the average FS ratio of the control group increased with slightly25%, on the contrast, the average FS ratio of the treatment group reduced by almost more than 50% in the end-line survey year.

From the equations (1) and (2), we know that the FS ratio depends on the ratio between food energy requirements and the energy available from on-farm production and off-farm income source in the entire year. In FSS ratio the energy is provided by on-farm production. Comparing the FS ratio and FSS ratio, we can see that FSS ratio had a high proportion of FS ratio in the end-line data, which means the energy available was mainly from the on-farm production. On the contrary, FSS ratio had a small proportion of FS ratio in the baseline survey, which illustrates that households depended more on off-farm income in the baseline survey, both for treatment and control households.

The reasons for the decrease in food security status in the end-line survey could be the increase in household size and the decline of farm size (*Table 3*). According to the relative change of family size and farm size, we can conjecture that the on-farm labor increased per acre which may strengthen the on-farm production. Other reasons may be that the outside job opportunities decreased or that outputs of crops increased in amount and price so that selling of on-farm produced surpluses contributed to higher FSS. While the off-farm income reduced dramatically in the end-line survey year, the improvement of on-farm production can not satisfy the family requirement which results in the decrease of FS ratio.

Above indicates that energy available from on-farm production plays a crucial role in the total energy requirement. We decide to use FSS ratio which is the ratio between food energy requirement of all household members and the energy available from on-farm production as an indicator to demonstrate the farmer's performance in the end-line survey study. Thus, in the following section, we used FSS ratio as an indicator to assess the project's impact and investigated factors' influence on farmer's performance regarding FSS ratio.

Table 4 Food secure and food self-sufficient status in the West Nile region

	Food secure		Food self sufficient	
	Base	End	Base	End
treatment group	80,579,1%	33,740%	29,28,3%	32,740%
Control group	80,45%	51,97,3%	41,142,7%	51,97,6%

Table 5 The average food security ratio and food self-sufficiency ratio of the West Nile region

		All households (n=429)	**Treatment group (n =120)**	**Control group (n =309)**
Av.FSS ratio	**End-line**	4,062,75±15,649,14	2,031,4±3,892,52	4,853,26±18,2310,58
	Base-line	1,3629±3,372,86	0,899±1,663	1,5444±3,719
	Change(%)	113198	12855	215126
Av.FS ratio	**End-line**	4,092,77±15,689,14	2,071,43±3,92,52	4,893,28±18,2910,58
	Base-line	4,3126±7,826	3,964,04±8,7499	4,4535±7,3451
	Change(%)	-355,1	-47,764,6	9,825
FSS ratio/ FS ratio (%)	**End-line**	99,2	98	99,1
	Base-line	31,530	22,24	34,633.1

3.3 The Impact of AS4Y project on Food Security

The end-line survey includes a control group (without AS4Y project activities) and a treatment group (with AS4Y project activities). The first part of impact evaluation used the **Before and After Approach** for the treatment group_to assess the impact of the AS4Y project. For the analysis, the treatmentgroup data were selected from baseline and end-line database. We applied Paired-Sample Test to both treatment and control groups. The results of Paired-Sample Test are presented in Appendix 2. The sample size of treatment group is 120 households. When using R-studio to apply sample t-test, the program removed the households without FS and FSS ratios. For nine families in the end line survey the FS ratio and/or FSS ratio could not be calculated. So the actual sample size of treatment group and control groups are 288 and 111households .respectively.

The Paired-Sample Test showed that, for treatment group, there wasis no a significant difference (p<> 0.05) between FS ratio of households after the project interventionin the baseline survey and before the project interventionin the end-line survey, in other words, the training did not haved a significant any impact on FS ratio which was unexpected. In the control group, the difference of FS between baseline survey and the end-line survey was not significantly.

As noted before, farmers focused on the on-farm activities in the end-line survey year. We applied sample t-test to compare FSS ratio of treatment and control groups in the end-line survey with the baseline survey. We found that FSS ratio in the end-line survey not very significantly differed from FSS ratio in the baseline (p<0.025>0.05) for the treatment group. However, for the control group, there is a significant difference between FSS ratio in baseline and end-line survey years (p<0.05). . The equation (1) indicates that food self-sufficiency ratio is used to evaluate whether the energy provided by on-farm production can satisfy the household's energy requirement in the whole survey year. The result illustrates that AS4Y project intervention has a significant impact on on-farm production. Comparing FS and FSS results we might assume that the project interventions shifted farmers' attention from off-farm to on-farm labor allocation. Because all project interventions focused on increasing crop production (Table 3.2 in Appendix 3).

We applied multiple regression analysis to the treatment group to see which factors influence farmers' food security and food self-sufficiency status in the end-line survey year. The results are presented in Figure 6a and 6b. The multiple regression analysis also was applied to the control group to correct other influence except for the project. The results are showed in Appendix 2. When ran the code to do the multiple regression analysis in R-studio, the program removed households without values of indicators the model required. So for the multiple regression analysis of treatment group, the actuathe l sample size of treatment and control groups wereis 87 and 227 respectively.

The results are shown in Figure 6a and Figure 6b indicates that . Except for household size significantly (p<0.01) negatively influenced FS and FSS ratios of the treatment group in the end-line survey. TLU and the number of crops with larger plant area in end-line survey significantly positive impact the FS and FSS ratios. O, other factors weakly related to the FS and FSS ratios. The strategy of increasing crop plant area also significantly increased the FS and FSS of the control group, which indicates that this predictor was a common factor for both treatment and control Wegroups. F can deduce that for the treatment group with AS4Y project intervention, the household size is the only limiting factor of FS and FSS ratios. when the household size The result indicates that Iincreasinged household size, the food requirement from household had a significantly adverse impact on FS ratio and FSS ratio Thisincreased. From results, we deduce that effect would likely be due to the rare off-farm opportunities for family members which can not release the pressure of on-farm consumption which results in the negative impact on FS ratio. TLU contributes to household income and direct access food. Thus, more animals improved food security ratio.

Figure 6~~6~~a Factors influencing the absolute FS ratio in the end-line survey for the treatment group

```
Call:
lm(formula = data_AS4Y$FSratio_end ~ Hhsize + FarmSize + stopCrop_num +
    startCrop_num + cropLessArea_num + cropMoreArea_num + UseTech +
    att_optimistic + att_religious + att_positive + att_escape +
    att_trapped + HHH_gender + TLU, data = data_AS4Y)

Residuals:
    Min      1Q  Median      3Q     Max
-4.0242 -0.9708 -0.3161  0.4450 10.9440

Coefficients:
                 Estimate Std. Error t value Pr(>|t|)
(Intercept)      -4.99903    2.96811  -1.684   0.0956 .
Hhsize           -0.15879    0.09263  -1.714   0.0899 .
FarmSize          0.06864    0.17207   0.399   0.6909
stopCrop_num     -0.68086    0.41893  -1.625   0.1076
startCrop_num     0.23771    0.33001   0.720   0.4732
cropLessArea_num  0.75916    0.43924   1.728   0.0873 .
cropMoreArea_num -0.18929    0.42031  -0.450   0.6535
UseTech           0.69933    0.60619   1.154   0.2517
att_optimistic    0.90107    0.55720   1.617   0.1093
att_religious     0.22033    0.24953   0.883   0.3796
att_positive      0.48598    0.34697   1.401   0.1647
att_escape       -0.02961    0.29539  -0.100   0.9204
att_trapped      -0.28672    0.22747  -1.260   0.2107
HHH_gender        0.27218    0.56873   0.479   0.6334
TLU               0.32179    0.13903   2.315   0.0229 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 2.401 on 91 degrees of freedom
  (7 observations deleted due to missingness)
Multiple R-squared:  0.246,	Adjusted R-squared:   0.13
F-statistic: 2.121 on 14 and 91 DF,  p-value: 0.01746
```

```
Call:
lm(formula = data_AS4Y$FSratio_end ~ Hhsize + FarmSize + stopCrop_num +
    startCrop_num + cropLessArea_num + cropMoreArea_num + UseTech +
    att_optimistic + att_religious + att_positive + att_escape +
    att_trapped + HHH_gender + TLU, data = data_AS4Y)

Residuals:
    Min      1Q  Median      3Q     Max
-5.9541 -1.8162 -0.7725  0.5716 19.6220

Coefficients:
                 Estimate Std. Error t value Pr(>|t|)
(Intercept)      -2.86768    5.23114  -0.548    0.585
Hhsize           -0.34446    0.17324  -1.988    0.050 *
FarmSize         -0.04094    0.30334  -0.135    0.893
stopCrop_num     -0.24124    0.72922  -0.331    0.742
startCrop_num     0.64463    0.57445   1.122    0.265
cropLessArea_num  1.08013    0.79097   1.366    0.176
cropMoreArea_num -0.41077    0.72125  -0.570    0.570
UseTech           0.42971    1.03794   0.414    0.680
att_optimistic    0.41821    0.98988   0.422    0.674
att_religious     0.32484    0.43135   0.753    0.453
att_positive      0.55726    0.59370   0.939    0.351
att_escape        0.09383    0.51173   0.183    0.855
att_trapped      -0.09603    0.38928  -0.247    0.806
HHH_gender        1.12099    1.01297   1.107    0.272
TLU               0.29392    0.23964   1.226    0.223
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 4.068 on 86 degrees of freedom
  (19 observations deleted due to missingness)
Multiple R-squared:  0.1369,	Adjusted R-squared:  -0.003614
F-statistic: 0.9743 on 14 and 86 DF,  p-value: 0.486
```

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Figure 6b Factors influencing the absolute FSS ratio in the end-line survey for the treatment group

```
Call:
lm(formula = data_AS4Y$FSSratio_end ~ Hhsize + FarmSize + stopCrop_num +
    startCrop_num + cropLessArea_num + cropMoreArea_num + UseTech +
    att_optimistic + att_religious + att_positive + att_escape +
    att_trapped + HHH_gender + TLU, data = data_AS4Y)

Residuals:
    Min      1Q  Median      3Q     Max
-4.0142 -0.9701 -0.3157  0.4491 10.9191

Coefficients:
                 Estimate Std. Error t value Pr(>|t|)
(Intercept)      -5.09049    2.96435  -1.717   0.0893 .
Hhsize           -0.15766    0.09251  -1.704   0.0918 .
FarmSize          0.07011    0.17185   0.408   0.6843
stopCrop_num     -0.68112    0.41840  -1.628   0.1070
startCrop_num     0.23676    0.32959   0.718   0.4744
cropLessArea_num  0.75722    0.43868   1.726   0.0877 .
cropMoreArea_num -0.18838    0.41978  -0.449   0.6547
UseTech           0.71143    0.60542   1.175   0.2430
att_optimistic    0.90733    0.55650   1.630   0.1065
att_religious     0.21912    0.24921   0.879   0.3816
att_positive      0.49037    0.34653   1.415   0.1604
att_escape       -0.02632    0.29502  -0.089   0.9291
att_trapped      -0.28813    0.22718  -1.268   0.2079
HHH_gender        0.27943    0.56801   0.492   0.6239
TLU               0.32088    0.13885   2.311   0.0231 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 2.398 on 91 degrees of freedom
  (7 observations deleted due to missingness)
Multiple R-squared:  0.2468,	Adjusted R-squared:  0.1309
F-statistic: 2.129 on 14 and 91 DF,  p-value: 0.01695
```

```
Call:
lm(formula = AS4Y.FSS$FSSratio_end ~ Hhsize + FarmSize + stopCrop_num +
    startCrop_num + cropLessArea_num + cropMoreArea_num + UseTech +
    +att_optimistic + att_religious + att_positive + att_escape +
    att_trapped + HHH_gender + TLU, data = AS4Y.FSS)

Residuals:
    Min      1Q  Median      3Q     Max
-5.9422 -1.7932 -0.7637  0.5978 19.5661

Coefficients:
                 Estimate Std. Error t value Pr(>|t|)
(Intercept)      -2.95149    5.22741  -0.565   0.5738
Hhsize           -0.34455    0.17312  -1.990   0.0497 *
FarmSize         -0.03942    0.30313  -0.130   0.8968
stopCrop_num     -0.24103    0.72870  -0.331   0.7416
startCrop_num     0.64725    0.57404   1.128   0.2627
cropLessArea_num  1.08658    0.79040   1.375   0.1728
cropMoreArea_num -0.41016    0.72074  -0.569   0.5708
UseTech           0.44884    1.03720   0.433   0.6663
att_optimistic    0.42122    0.98917   0.426   0.6713
att_religious     0.31675    0.43104   0.735   0.4644
att_positive      0.55611    0.59327   0.937   0.3512
att_escape        0.10210    0.51137   0.200   0.8422
att_trapped      -0.09165    0.38900  -0.236   0.8143
HHH_gender        1.13654    1.01225   1.123   0.2647
TLU               0.29569    0.23947   1.235   0.2203
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 4.065 on 86 degrees of freedom
  (19 observations deleted due to missingness)
Multiple R-squared:  0.137,	Adjusted R-squared:  -0.003507
F-statistic: 0.975 on 14 and 86 DF,  p-value: 0.4853
```

3.4 Multiple Regression Analysis

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In order to see what might account for the difference in households' performance in terms of food security ratio and food self-sufficiency ratio between 2013 and 2016, the multiple regression analysis was applied to test which factor affects the increase or decrease of these ratios significantly. The gain in FS ratio is calculated by taking the FS ratio in baseline study and subtracting it from the FS ratio in the end-line study. We applied the **With and Without Approach** to assess the project's impact which targets the whole sample. We used the same procedure to FSS ratio. Due to the uncompleted information the sample size for testing the gain of FS ratio and FSS ratio were 323 and 325337 households. respectively.

The results of the analysis for the progress of FS ratio and FSS ratio are presented in Figure 7a and Figure 7b respectively. The test results indicate that AS4Y project didn't had a significantly negative impact ve any impact on increasing food security ratio and food self-sufficiency ratio which is contrary to the objective of the AS4Y project. but whichThe significant influence of AS4Y project is in line with the findings from the sample paired T-test. The non-relationship between project and FS and FSS ratios could be the domination of control group's influence because 72% of farmers in the whole sample size are from the control group. Similar findings were found by Kansiime (2014) in the baseline report of AS4Y project which indicates that the extension service showed a significant adverse impact on VOP in Moyo and Nebbi districts. Benin (2007) also indicates less favorable outcomes of extension service on agricultural productivity in Uganda. For the unfavourableunfavorable results, on the one hand, we doubt the efficiency and accuracy of the project's execution. Because from observation, a majority of farmers were trained by other model farmers. The farmer to farmer message delivery chain raises questions on the value of training. On the other hand, only 28% of households received AS4Y project in the whole survey On the other hand, . it could be TThe unequal different sample size of treatment and control groups which leads to the impact domination of control group. What's more, the project training results relates to the adoption of new production technologies thus improving productivity. The questions about the adoption of technologies provided by AS4Y should be surveyed.

The strategy of technologies adaptation(UseTech) significantly ($p<0.01$) decreased gain in FS ratio and to a lesser extend in FSS ratio which means trying newmodified techniques farmers have been trained offers a food security risk for most small-scale farmers. Figure3 indicated that about 40% of families in the control group took the technology adaptation, whereas only around 20% of households in the treatment group modified technologies. Technology adaptation showed positive signs on the absolute FS and FSS ratios for the treatment group (*Figure 6*). We can, therefore, speculatetherefore, speculate that the adverse impacts are mainly from the control group, as a great proportion of farmers in the control group took the technology adaptation. We doubt that farmers in the control group did receive good instructions from extension service, and most small-scale farmers in the study area were not ready for technology adaptation. Farmers prefer to use the technology they are familiar with, and are interested in technologies which can satisfy their income needs immediately. Having the ability to modify or integrate technologies they have been trained is a big move for farmers. But without the right instruction, the results will not be favorable.

Starting to plant more crops improved the FS ratio and FSS ratio significantly ($p<0.01$). Farmers started to cultivate a new crop which caters the market and household demands *(Figure 5)*, this results in a good FS and

FSS ratios in this study. The strategy of changing cropland was not strongly correlated with the gain in FS ratio and FSS ratio. Because of limited farm size, increasing one crop's cultivated area means reducing another crop's plant area. The effects of rearranging land allocation are counteracting, so the impacts were not significant. The suggestion for farmers is to plant more crop types which cater market and household demand and have higher productivity to improve ~~their FS ratio and FSS ratio~~the on-farm production.

Figure 7a The results of multiple regression analysis for the progress of FS ratio in the sample group

```
Call:
lm(formula = dataFS$FSratio_gain ~ Project + Hhsize + FarmSize +
    stopCrop_num + startCrop_num + cropLessArea_num + cropMoreArea_num +
    UseTech + att_optimistic + att_religious + att_positive +
    att_escape + att_trapped + HHH_gender + TLU, data = dataFS)

Residuals:
    Min      1Q  Median      3Q     Max
-85.481  -2.464   0.111   2.589 112.383

Coefficients:
                 Estimate Std. Error t value Pr(>|t|)
(Intercept)       8.94495    5.07872   1.761  0.07910 .
Project          -2.56122    1.54100  -1.662  0.09743 .
Hhsize            0.01426    0.15813   0.090  0.92817
FarmSize          0.41861    0.40474   1.034  0.30175
stopCrop_num     -0.21872    0.91647  -0.239  0.81152
startCrop_num     1.10798    0.80442   1.377  0.16932
cropLessArea_num -0.26062    1.34063  -0.194  0.84598
cropMoreArea_num -0.27263    1.03475  -0.263  0.79234
UseTech          -3.13084    1.43494  -2.182  0.02981 *
att_optimistic    0.21797    0.87251   0.250  0.80288
att_religious     0.45014    0.55446   0.812  0.41744
att_positive     -1.82849    0.78429  -2.331  0.02032 *
att_escape       -0.13821    0.60502  -0.228  0.81945
att_trapped      -1.58796    0.48401  -3.281  0.00114 **
HHH_gender       -3.51373    1.47309  -2.385  0.01762 *
TLU               0.20500    0.22107   0.927  0.35444
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 11.99 on 336 degrees of freedom
  (58 observations deleted due to missingness)
Multiple R-squared:  0.1069,    Adjusted R-squared:  0.06703
F-statistic: 2.681 on 15 and 336 DF,  p-value: 0.0007075
```

```
Call:
lm(formula = data$FSratio_gain ~ Project + Hhsize + FarmSize +
    stopCrop_num + startCrop_num + cropLessArea_num + cropMoreArea_num +
    UseTech + att_optimistic + att_religious + att_positive +
    att_escape + att_trapped + HHH_gender + TLU, data = data)

Residuals:
    Min      1Q  Median      3Q     Max
-87.214  -4.406  -0.453   3.304 200.703

Coefficients:
                 Estimate Std. Error t value Pr(>|t|)
(Intercept)      11.79246    7.33413   1.608   0.1088
Project          -3.23259    2.24602  -1.439   0.1511
Hhsize           -0.04436    0.23293  -0.190   0.8491
FarmSize          0.75895    0.60408   1.256   0.2099
stopCrop_num     -0.48532    1.32267  -0.367   0.7139
startCrop_num     2.76187    1.17003   2.361   0.0188 *
cropLessArea_num -1.49112    1.98215  -0.752   0.4524
cropMoreArea_num -0.01993    1.50531  -0.013   0.9894
UseTech          -4.97713    2.08533  -2.387   0.0176 *
att_optimistic    0.17488    1.27938   0.137   0.8914
att_religious     0.58168    0.80399   0.723   0.4699
att_positive     -2.39077    1.13773  -2.101   0.0364 *
att_escape       -0.04835    0.87586  -0.055   0.9560
att_trapped      -1.70527    0.71136  -2.397   0.0171 *
HHH_gender       -3.65281    2.15984  -1.691   0.0918 .
TLU               0.27076    0.31866   0.850   0.3961
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 17.13 on 322 degrees of freedom
  (91 observations deleted due to missingness)
Multiple R-squared:  0.1022,    Adjusted R-squared:  0.06033
F-statistic: 2.443 on 15 and 322 DF,  p-value: 0.002163
```

Figure 7b The results of multiple regression analysis for the progress of FSS ratio in the sample group.

```
Call:
lm(formula = dataFSS$FSSratio_gain ~ Project + Hhsize + FarmSize +
    stopCrop_num + startCrop_num + cropLessArea_num + cropMoreArea_num +
    UseTech + att_optimistic + att_religious + att_positive +
    att_escape + att_trapped + HHH_gender + TLU, data = dataFS)

Residuals:
    Min      1Q  Median      3Q     Max
-51.639  -2.654  -0.890   0.834 112.154

Coefficients:
                 Estimate Std. Error t value Pr(>|t|)
(Intercept)        6.2604     3.9934   1.568   0.1179
Project           -1.6411     1.2117  -1.354   0.1765
Hhsize            -0.0213     0.1243  -0.171   0.8641
FarmSize           0.3795     0.3182   1.193   0.2339
stopCrop_num      -0.1379     0.7206  -0.191   0.8483
startCrop_num      1.3995     0.6325   2.213   0.0276 *
cropLessArea_num  -1.4027     1.0541  -1.331   0.1842
cropMoreArea_num  -0.1780     0.8136  -0.219   0.8270
UseTech           -2.3968     1.1283  -2.124   0.0344 *
att_optimistic     0.1225     0.6861   0.179   0.8584
att_religious      0.5600     0.4360   1.284   0.1999
att_positive      -1.1349     0.6167  -1.840   0.0666 .
att_escape        -0.1121     0.4757  -0.236   0.8139
att_trapped       -0.5918     0.3806  -1.555   0.1209
HHH_gender1       -2.2208     1.1583  -1.917   0.0560 .
TLU                0.1404     0.1738   0.807   0.4200
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 9.431 on 336 degrees of freedom
  (58 observations deleted due to missingness)
Multiple R-squared:  0.07776,   Adjusted R-squared:  0.03659
F-statistic: 1.889 on 15 and 336 DF,  p-value: 0.02339
```

```
Call:
lm(formula = data$FSSratio_gain ~ Project + Hhsize + FarmSize +
    stopCrop_num + startCrop_num + cropLessArea_num + cropMoreArea_num +
    UseTech + att_optimistic + att_religious + att_positive +
    att_escape + att_trapped + HHH_gender + TLU, data = data)

Residuals:
    Min      1Q  Median      3Q     Max
-56.717  -4.325  -1.035   1.401 200.616

Coefficients:
                 Estimate Std. Error t value Pr(>|t|)
(Intercept)       8.71373    6.62562   1.315  0.18939
Project          -2.71370    2.02440  -1.340  0.18102
Hhsize           -0.08565    0.21019  -0.407  0.68392
FarmSize          0.61420    0.54575   1.125  0.26124
stopCrop_num     -0.38407    1.19445  -0.322  0.74801
startCrop_num     3.00197    1.05557   2.844  0.00474 **
cropLessArea_num -2.33664    1.78494  -1.309  0.19143
cropMoreArea_num  0.05641    1.35736   0.042  0.96688
UseTech          -4.05923    1.87638  -2.163  0.03125 *
att_optimistic    0.12793    1.15515   0.111  0.91189
att_religious     0.66714    0.72509   0.920  0.35822
att_positive     -1.70440    1.02516  -1.663  0.09737 .
att_escape        0.08256    0.79022   0.104  0.91685
att_trapped      -0.63170    0.63841  -0.989  0.32316
HHH_gender       -2.52554    1.94343  -1.300  0.19469
TLU               0.22668    0.28764   0.788  0.43124
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 15.48 on 324 degrees of freedom
  (89 observations deleted due to missingness)
Multiple R-squared:  0.08081,   Adjusted R-squared:  0.03826
F-statistic: 1.899 on 15 and 324 DF,  p-value: 0.02257
```

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People's general speculation about the impact of attitudes on the performance are *optimistic* holders show positive influence and *trapped* owners show negative consequence. Thus we expected that the *trapped* attitude significantly ($p<0.01$) decreased the progress of FS ratio and that the *Escapist* would also have a negative sign. To our surprise, we found that *positive* attitude had a significantly ($p<0.05$) negative impact on FS and FSS ratios. These findings might infer that when the constraints of agriculture are not removed although farmers hold an active willingness towards farming, the FS and FSS ratios are hard to improve. While compare to Figure 6a and 6b, *positive* attitude showed positive sign of FS and FSS ratios in the treatment group. Thus we deduce that the control group dominated the results which mean most *positive* attitude holders in the control group reduced FS and FSS ratios in the end-line survey year. In figure 7*a* and 7b, *trapped* attitude showed a significant ($p<0.01$) negative relation with FS ratio and had a negative sign of FSS ratio. These findings confirm results in Figure 6a and 6b where *trapped* holders showed negative sign as well.

The gender of the household head demonstrated a significant impact on the progress of FS and FSS ratios (Figure 7~~a~~). Female-headed households are more likely to improve the ~~food security~~FS and FSS ratio than the male-headed households. Table 6 summarizes families' characteristics in the study region. The average family size, land size and TLU were slightly different between female-headed households and male-headed households in the end-line survey year. However, the outcomes of FS and FSS ratios were very different. The average FS ratio increased slightly in the female-headed families but decreased in the male-headed group. The proportion of farmers achieved food security reduced by ~~25~~30% and ~~27~~35% in the female-headed and male-headed groups respectively. Moreover, the percentage of food self-sufficiency farmers increased 13~~9~~% ~~and 15%~~ in the female-headed and decreased 5% in the male-headed group respectively. Kennedy and Peters (1992) indicated that families' food energy intake positively correlated with the level of household income dominated by the female which might be one reason for the good performance of female-headed households. Another reason for this is the continuous facilitation by extension service which targets female farmers. As in general, the household head is male, we can assume that the females were the head of the family when the male migrated, when the female has higher education or she is a widow. Reception of high remittances can be a reason for higher average FS ratio of the female-headed group. Future study can investigate the education level of household head that we missed in this survey.

As the larger the farm size, the higher the crop production, we expected a positive correlation between farm size and food security ratio. Increasing household size directly increases the households' energy requirement and decrease the income per head. We expect a negative relationship between family size and food security ratio. Table 6 shows the decline of farm size and the increase in family size in the end-line survey year resulted in an improvement in FS and FSS ratios which is unexpected. The increase of average cassava yield infers the improvement of on-farm production which can explain why the FSS ratio improved. What's more, results from multiple regression analysis for female-headed farmers (Appendix 2) shows that household size and farm size didn't significantly influence the gain in FS and FSS ratios. The strategy of diversifying crop and TLU significantly positively impact the progress of FS and FSS. The strategy of increasing a crop's plant area and trapped farmer significantly lowered the gain in FS and FSS. *Trapped* attitude negatively influenced the FS ratio of male-headed group (Appendix2 Table2.10). Only TLU, strategy of changing cropland and crop patterns affect the female-headed group in our study.

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For both male and female headed households in the baseline, FSS ratio was much lower than FS ratio which indicates the high dependency on off-farm income. In the end-line study, FS and FSS ratio were almost equal indicating that off-farm income disappeared for both groups. And in end-line survey FSS ratio improved a lot. We can confirm that the gender is a strong indicator for on-farm food and income.

Table 6 The summary of gender group

Whole sample group (n=412)	Av.Family size (person)		Av.Farm size (acres)		Av.cassava yield(kg/acre)		Av. TLU		Av. FS ratio		Av.FSS ratio		Food secure(%)		Food self-sufficient(%)	
	Base	End	Base	End	Base	End	Base	End	Base	End	Base	End	Base	End	Base	End
Female-headed (n=109)	6.94 ±3.12	8.94 ± 5.23	3.49 ±2.24	2.43 ± 1.25	1157.77± 649.8	2716.66± 5633.18	1.75 ±3.01	1.75 ± 2.01	3.46 ±4.08	3.53±15.179.73	1.21±1.72	4.613.51 ±15.19.7	83%	5752.2%	39%	5852.2%
Male-headed (n=303)	6.84 ± 2.7	8.45 ± 3.85	3.52 ± 2.32	2.54 ± 1.88	1077.87± 636.9	3127.15± 10519.71	1.66 ± 2.28	2.32 ± 3.5	4.63 4.53 ±8.9278	3.952.49 ±16.068	1.342± 3.1873	3.912.48 ±16.038	80%	5345 %	5938%	44.553%

3.5 Technology Adaptation

In the previous analysis, technology adaptation showed a negatively significant impact on improved FS ratio and FSS ratio. Multiple logistic regression analysis was performed on the end-line household data for all households to explore what might account for the technology adaptation variation. The results of the regression analysis are presented in Figure 9.

It was presumed that farmers who participated in the project had a higher probability of technology adaptation. However, the result of the regression model shows the project variable has a very significant negative impact ($p<0.001$) on technology adaptation. The AS4Y project probably did not encourage farmers in the treatment group to modify new technologies when considering the farmers' actual situation. For the further program which aims to support farmers to become innovators, the following results might provide some inspiration.

We expected farm size has a very significant ($p<0.01$) positive influence on technology adaptation. Farm size is a sign of wealth so that larger farmers can afford the investment. Similar results have been reported by Knowler & Bradshaw (2007). We can infer that smallholders are under higher risk to the technology adaptation than farmers with large land size because of the limited farming area and uncertain results of technology.

The strategy of changing crop species had a significant ($p<0.01$) impact on technology adaptation. Figure 8 indicates that with fewer crops on the farm, the probability of technology adaptation significantly increased, which means they rather intensify than diversify crops. Comparing to farmers who focus on fewer crops, farmers with diverse crops need more inputs, and each plant needs its own strategy of technology adaptation which is not easy to carry out. Changing cropland allocation did not show a significant effect on technology adaptation. We can say that farmers who focus on fewer crops have more possibility to become innovators whereas changing land allocation did not matter.

Figure 8 Results of the multiple logistic regression analysis

```
Call:
glm(formula = UseTech ~ Project + Hhsize + FarmSize + stopCrop_num +
    startCrop_num + cropMoreArea_num + cropLessArea_num + att_optimistic +
    att_religious + att_positive + att_escape + att_trapped +
    FSratio_base + HHH_gender + TLU, family = binomial(link = "logit"),
    data = dataR, weights = na.action(na.omit))

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-1.9440  -0.9203  -0.5661   0.9974   2.3590

Coefficients:
                 Estimate Std. Error z value Pr(>|z|)
(Intercept)      -2.09291    1.02736  -2.037  0.04163 *
Project          -1.32115    0.30210  -4.373 1.22e-05 ***
Hhsize            0.01924    0.02922   0.658  0.51029
FarmSize          0.28588    0.09066   3.153  0.00161 **
stopCrop_num      0.37917    0.16726   2.267  0.02339 *
startCrop_num    -0.34931    0.15268  -2.288  0.02214 *
cropMoreArea_num  0.02611    0.19650   0.133  0.89428
cropLessArea_num  0.09148    0.25774   0.355  0.72264
att_optimistic    0.59297    0.19121   3.101  0.00193 **
att_religious    -0.07038    0.10470  -0.672  0.50144
att_positive     -0.19830    0.15044  -1.318  0.18748
att_escape        0.01903    0.11288   0.169  0.86611
att_trapped      -0.07673    0.09255  -0.829  0.40709
FSratio_base      0.02344    0.01451   1.615  0.10629
HHH_gender       -0.69773    0.27379  -2.548  0.01082 *
TLU              -0.05788    0.04559  -1.269  0.20431
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 473.14  on 351  degrees of freedom
Residual deviance: 403.99  on 336  degrees of freedom
  (58 observations deleted due to missingness)
AIC: 435.99

Number of Fisher Scoring iterations: 4
```

```
Call:
glm(formula = UseTech ~ Project + Hhsize + FarmSize + stopCrop_num +
    startCrop_num + cropMoreArea_num + cropLessArea_num + att_optimistic +
    att_religious + att_positive + att_escape + att_trapped +
    FSratio_base + HHH_gender + TLU, family = binomial(link = "logit"),
    data = dataR, weights = na.action(na.omit))

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-1.9405  -0.9197  -0.5646   0.9964   2.3541

Coefficients:
                 Estimate Std. Error z value Pr(>|z|)
(Intercept)      -2.15629    1.02677  -2.100  0.03572 *
Project          -1.32169    0.30247  -4.370 1.24e-05 ***
Hhsize            0.02048    0.02921   0.701  0.48314
FarmSize          0.29256    0.09069   3.226  0.00126 **
stopCrop_num      0.37238    0.16707   2.229  0.02582 *
startCrop_num    -0.36689    0.15262  -2.404  0.01622 *
cropMoreArea_num  0.02998    0.19554   0.153  0.87815
cropLessArea_num  0.10623    0.25625   0.415  0.67848
att_optimistic    0.59819    0.19127   3.127  0.00176 **
att_religious    -0.07394    0.10428  -0.709  0.47829
att_positive     -0.20239    0.14963  -1.353  0.17619
att_escape        0.02613    0.11193   0.233  0.81539
att_trapped      -0.06789    0.09211  -0.737  0.46110
FSratio_base      0.02492    0.01437   1.734  0.08290 .
HHH_gender       -0.70494    0.27347  -2.578  0.00994 **
TLU              -0.05703    0.04536  -1.257  0.20869
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 478.86  on 355  degrees of freedom
Residual deviance: 408.05  on 340  degrees of freedom
  (73 observations deleted due to missingness)
AIC: 440.05

Number of Fisher Scoring iterations: 4
```

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A very positively significant effect ($p<0.001$) of *optimists* was as expected which means the optimists were more likely to become an innovator. The *trapped* farmer was more likely (although not significantly) refusing to become an innovator just as we expected. *Positive* attitude holders are willing to invest money. The unexpected negative sign of *positive* attitude might implicate that when farmers take farming as a more serious business, they might be afraid of taking the risk and refuse to change, or they are already good producers and do not need to change. *Escape* farmers treat farming as an alternative choice and hope next generation does not end up working as a farmer. The unexpected positive sign of *escape attitude* could be farmers wanted to change their situation by modifying technologies to improve the crop production. Table 7 summarizes the sign of attitudes from Figure ~~8~~6,7 and 8. When compare the results in Table 7, we found that attitudes had the same sign of gain in FSS ratio and technology adaptation except *religious*. Thus we speculate that for different attitudes group, the strategy of technology adaptation might positively correlate with the increase in FSS ratio. *Optimistic* farmers were more likely to modify technology, and the *positive* attitude might improve the FS and FSS ratios. And *trapped* farmers were not likely to modify technologies, and this attitude might negatively contribute to FS and FSS ratio. These findings confirmed our assumption.

Table 7 The summary of the sign of attitudes

	Optimistic	*Religious*	*Positive*	*Escape*	*Trapped*
FS ratio of treatment group	+	+	+	+	-
FSS ratio of treatment group	+	+	+	+	-
gain in FS ratio	+	+	-*	-	-*
Gain in FSS ratio	+	+	-.	+	-
Technology adaptation	+ *	-	-	+	-

*Significant code: 0 "***" 0.001 "**" 0.01"*" 0.05"." 0.1 "" 1*

~~Food security ratio of household represents the financial status. Figure 9 showed that the original food security ratio positively significant (p<0.05) influenced the innovation to technology. It shows that farmers under good food security situation were able to accept challenges, so they were willing to take the risk of modifying technology. TLU also typically represents household's wealth status, but it appeared with a negative sign in the analysis. TLU also showed a negative sign of VOP in the baseline report. The livestock production might only be the key point for farmers with high TLU in the baseline survey, and the only technology related to animal production is the nutrient management (Appendix 4). Most farmers are crop farmers, and TLU has no direct relation with improved technology for cropping.~~

A significant impact ($p<0.001$) of the gender of household head on technology adaptation was found in this study. The results indicate that female-headed households are significantly more ready to adapt the technology they were trained.

3.6 Reflection

The technology adaptation in this study stands for the procedure of modifying technologies farmers have been trained through projects interventions. We suppose that AS4Y project can help farmers to enhance the ability of problem-solving and to put the acknowledge and skills they learnt from project interventions into practical. In this study technology adaptation is expected to reflect these outcomes, so that farmers can solve food insecurity problems independently in the future and after the completion of the project.

The impact of AS4Y project interacted with other projects because the farmers in the study also received other extension services. Therefore, we can not evaluate the technology adaptation only from the AS4Y project. Moreover, the technology adaptation survey could not target specific technologies, because different technology packages were delivered to farmers. Some unique technologies that only provided by AS4Y are not included in the questionnaire. The AS4Y project's influence on technology adaptation should be asked by targeting to specific technologies which were delivered by AS4Y.

Due to the unfavorable outcomes of project interventions on food security, we used the crop yield as an indicator to see the influence of project. Cassava is the most common food that farmers had in both end-line and base line survey year. We tested the difference in cassava yield between baseline and end-line survey years for control and for treatment group. The results are presented in Appendix 2. The results show that there is no significant difference in cassava yield between 2013 and 2016 for both control and treatment groups.

To see the effect of technology adaptation on cassava yield, the paired sample t test was used to the group applied technology adaptation and to the group without technology adaptation. The tests outcomes are showed in Appendix2. We found that the strategy of technology adaptation didn't result in a significant difference in cassava yield between baseline and end-line survey years.

The sample size of the control group is larger than the treatment group. Thus the control group might dominate the results when the analysis targeted all the sample group. We suggest the sample size of control and treatment equally for the next survey.

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The distribution of treatment group farmers in every district is not equal. Most farmers are from Moyo and Arua districts. Farmers from Zombo, Nebbi and Koboko are less than ten each. The local weather, farming and market conditions are different which results in a huge variation in the outcomes is huge. The different sample size makes that the analysis in a specific district is non-presentable.

The end-line survey questionnaire was largely based on the baseline survey questionnaire. But some adjustments in the end-line survey questionnaire were found not ideal after the analysis. The livestock management and dominant fodder type in the livestock production section were removed in the end-line survey questionnaire, but this information would have been useful to interpret the change of TLU. The question of labor cost was asked twice in two different ways, but the answers from farmers were different. In the analysis, we only can choose one answer which might cause different results. We also lacked data on the education level of household head. We suggest to include this part in the next survey. Not all the farmers answered all questions of the questionnaire which caused the sample size of different analysis is different. When doing statistic calculation and multiple regression analysis by using R-Studio, the program removed the households without value.

The attitude evaluation is from Melissa (2002)'s finding. Melissa (2002) applied the TNS segmentation which is a screener tool developed to classify farmers into segments quickly. But this tool is not available for this study. If access to this tool can be provided, the attitude classification can be improved by using the TNS segmentation tool.

Statistics was useful to present the correlation between factors. Some poor relations were found during the statistic analysis. The strategy of changing cropland allocation didn't relate to FS and FSS ratios. This non-relationship sign might because of the limited and reduced farming land in the end-line survey year. And the farm size also weakly related to FS and FSS ratios. Household size was strongly negative correlated with FS and FSS ratios of the treatment group. But it showed a negatively non-significant sign of the gain in FS and FSS ratio. Thus, we deduce that the household member might contribute to on-farm and off-farm activities for improving FS and FSS ratios in the control group. So farmers relieved the pressure on household consumption.
The *religious* attitude holders showed a positive non-significant sign ($p>0.05$) on the FS and FSS ratios and the ability of technology adaptation. We can speculate that even religion is a weak factor for improving farmers' livelihood, but it might positively contribute to farming decision making.

TLU owned by families was expected to be positivity related to FS ratio and FSS ratio. However, for treatment group, this study found that the impact of TLU on FS and FSS ratios was not significant. The TLU in the base-line survey also showed a non-significant influence on VOP in the base-line report. This founding verifies that in the study area farmers focus on crop production.

Survey is a good way to show the outcomes of HH after project interventions. By comparing the data in baseline and end-line, we can see changes in each farm, the difference between control and treatment groups, and derive relevant results. The end-line survey implemented by ten enumerators with an agricultural background and from the surveying district to ensure that we received the accurate information from farmers. Because of the long travel distance with bad road condition between each district, and the limited survey time, the farms observed by the researcher are not representable. Visiting the presentable for direct observation is necessary for a researcher to understand some particular phenomenon.

4 Conclusions and Recommendations

4.1 Conclusions

The on-farm production was responsible a great proportion of the total household caloric intake in the end-line survey year. We found that the AS4Y project had a has a positive impactnegative impact in terms of food self-sufficiencysecurity, as the results illustrated that the food self-sufficiencysecurity ratio of treatment group showed a significant difference between the end-line survey and baseline survey. However, the project doesn't have any impact on food security self-sufficiency ratio. What's more, the proportion of farmers that achieved food security decreased in both control and treatment groups, but the percentage of farmers that fulfilled food self-sufficiency increased in both groups. The results showed that farmers shifted their key livelihood source from off-farm activity to on-farm production. And the project has a significantly positive influence on on-farm production. For farmers who attended the AS4Y project, household size is the onlyand TLU are factors that significantly influenced FS and FSS ratios.

The multiple regression analysis confirms that diversifying plant variety by starting cultivating new crops improves the FS and FSS ratios. The survey indicated that market demand is the key factor that farmers considered when changing crop varieties. High labor input and low crop's productivity were often mentioned by farmers as reasons to stop cultivating certain crops. Farmers who started to plant new crops always thought about household demand, the value of crops and the productivity of crops. Thus, diversifying crop patterns contributed to the FSS ratio.

However, the strategy of adapting technologies that farmers haves been trained significantly negatively affected the progress of FS ratio and FSS ratio. Therefore, improving the food security ratio and encouraging farmers to become innovator are contradictory in this study.

Gender of household head is another factor that significantly influenced the gain of FS ratio and technology adaptation. The results showed that female-headed households performed better than male-headed families to strengthen ~~food security ratio~~FSS and FS ratios and become an innovator. Moreover, farmers who focus on fewer crops are more likely to become an innovator

The study substantiates that large farm size indicates greater wealth and farm size shows a significant positive impact on the possibility to innovate technology. ~~Also, a good financial situation expressed by the FS ratio is an important factor for technology adaptation.~~ This is probably because ~~large farms~~wealthy farmers have more capital available to invest.

The data suggest a clear-cut effect for the attitude factor that *optimistic* attitude holders are more likely than other view holders to become innovators. ~~and have the possibility to improve the FS and FSS ratios. The *trapped* attitudes farmers might refuse to modify technologies.~~ The *trapped* attitude significantly negative influenced the progress of FS ~~and also have the possibility to lower the FSS ratio~~.

4.2 Recommendations

For the small-scale farmers who aims to feed their family, we encourage them to diversify through including new crop varieties which can satisfy the food requirement from households and improve their tolerance against risks from the market. The FS ratio will be enhanced consequently. For the families that already achieved food security, we suggest them to focus on fewer crops and encourage them to innovate technology they already learnt.

The future extension service can target to some area that rarely has access to extension service, which can help farmers significantly and the impact of the project can be assessed more precise. And evaluate more quantitative information like the productivity of the plot area per acre and soil fertility before and after project interventions will be helpful. Continue to target female farmers is recommended as they prove to strengthen the FS ratio and modify technologies.

One point that goes beyond our expectation is that households in the survey area shifted their main source of household income from off-farm income to on-farm production. This strategy might have a significant influence on the annual household income. Future research could investigate why farmers made this change.

Reference

1. Agriculture and Food Security | Uganda | U.S. Agency for International Development. *(2015).* Usaid.gov*. Retrieved 10 August 2016, from https://www.usaid.gov/uganda/agriculture-and-food-security*

2. Agriculture in Uganda*. (2016).* En.wikipedia.org*. Retrieved 28 October 2016, from https://en.wikipedia.org/wiki/Agriculture_in_Uganda*

3. *Agriculture. (2016). Ceford.org.ug. Retrieved 1 August 2016, from http://www.ceford.org.ug/index.php/focus-areas/agriculture*

4. *Ajzen, I., 1991. The theory of planned behavior. Organizational Behavior and Human Decision Processes 50, 179-211.*

~~4.~~5. *Maize Flour | AGMIS*. (2016). *Agmis.infotradeuganda.com*. Retrieved 21 December 2016, from http://agmis.infotradeuganda.com/commodity/view/id/Nw==

~~5.~~6. Asfaw, A., & Admassie, A. (2004). The role of education on the adoption of chemical fertiliser under different socioeconomic environments in Ethiopia.*Agricultural Economics*, *30*(3), 215-228.

~~6.~~7. *Baker, Melissa (2012) Do Attitudes Matter?, paper presented at a workshop organized by the social and political division of TNS East African and funded by the Bill and Melinda Gates Foundation and held on 13 November in Nairobi, Kenya.*

~~7.~~8. *Benin, S., Nkonya, E., Okecho, G., Pender, J., Nahdy, S., Mugarura, S., Kato, E. and Kayobyo, G., (2007).Assessing the Impact of the National Agricultural Advisory Services (NAADS) in the Uganda Rural Livelihoods. IFPRI Discussion Paper 724, October 2007. Washington DC: International Food Policy Research Institute.*

~~8.~~9. *Birungi, P. B. (2007). The linkages between land degradation, poverty and social capital in Uganda (Doctoral dissertation, University of Pretoria South Africa).*

~~9.~~10. *Bozeman, B. (2000). Technology transfer and public policy: a review of research and theory. Research Policy 29, 627-655.*

~~10.~~11. *Delener, N. (1994). Religious Contrasts in Consumer Decision Behaviour Patterns: Their Dimensions and Marketing Implications.* European Journal Of Marketing*, 28(5), 36-53. http://dx.doi.org/10.1108/03090569410062023*

~~11.~~12. *Deressa, T., Hassan, R., Ringler, C., Alemu, T. and Yesuf, M. (2009). Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia.* Global Environmental Change*, 19(2), pp.248-255.*

~~12.~~13. FAO. (2001). *Food balance sheet—A handbook*. Rome: FAO.

~~13.~~14. FAO. 2002. *The State of Food Insecurity in the World 2001*. Rome pp. 4-7.

~~14.~~15. *Franzel, S. (1999). Socioeconomic factors affecting the adoption potential of improved tree fallows in Africa. Agroforestry systems, 47(1-3), 305-321.*

~~15.~~16. *Fuglie, K.O., 1999. Conservation tillage and pesticide use in the cornbelt. Journal of Agricultural and Applied Economics 31 (1), 133–147.*

~~16.~~17. *Hassan, R., & Nhemachena, C. (2008). Determinants of African farmers' strategies for adapting to climate change: Multinomial choice analysis. African Journal of Agricultural and Resource Economics, 2(1), 83-104.*

~~17.~~18. *Innovation. (2016). Wikipedia. Retrieved 27 July 2016, from https://en.wikipedia.org/wiki/Innovation*

~~18.~~19. *Jones, A., Ngure, F., Pelto, G., & Young, S. (2013). What Are We Assessing When We Measure Food Security? A Compendium and Review of Current Metrics.* Advances In Nutrition: An International Review Journal*, 4(5), 481-505. http://dx.doi.org/10.3945/an.113.004119*

~~19.~~20. Kansiime, M. (2015). Household livelihood strategies and implications for food security and food self- sufficiency: A case of West Nile, Uganda.

~~20.~~21. *Karki, L. B., & Bauer, S. (2004). Technology adoption and household food security. Analyzing factors determining technology adoption and impact of project intervention: A case of smallholder peasants in Nepal. Deutscher Trope tag, 5-10.*

~~21.~~22. *Kebede, Y. (1990). Adoption of new technologies in Ethiopian agriculture: The case of Tegulet-Bulga district Shoa province.* Agricultural Economics*, 4(1), 27-43. http://dx.doi.org/10.1016/0169-5150(90)90018-v*

~~22.~~23. Kennedy, E. & Peters, P. (1992). Household food security and child nutrition: the interaction of income and gender of household head. World Development, 20(8), 1077-1085. http://dx.doi.org/10.1016/0305-750x(92)90001-c

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~~23.~~24. *Knowler, D. & Bradshaw, B. (2007). Farmers' adoption of conservation agriculture: A review and synthesis of recent research.* Food Policy*, 32(1), 25-48. http://dx.doi.org/10.1016/j.foodpol.2006.01.003*

~~24.~~25. Luan, Y., Cui, X., & Ferrat, M. (2013). Historical trends of food self-sufficiency in Africa. Food Security, 5(3), 393-405. http://dx.doi.org/10.1007/s12571-013-0260-1

~~25.~~26. *Lynne, G. D., Casey, C. F., Hodges, A., & Rahmani, M. (1995). Conservation technology adoption decisions and the theory of planned behavior. Journal of economic psychology, 16(4), 581-598.*

~~26.~~27. *Nyangena, W. (2007). Social determinants of soil and water conservation in rural Kenya.* Environ Dev Sustain*, 10(6), pp.745-767.*

~~27.~~28. *Okoth, J., Khisa, G., & Thomas, J. (2002). Towards a holistic farmer field school approach for East Africa. LEISA-LEUSDEN-, 18, 18-19.*

~~28.~~29. *Our Africa,. (2016).* Climate & Agriculture*. Retrieved 24 February 2016, from http://www.our-africa.org/uganda/climate-agriculture*

~~29.~~30. *Paired Sample T-Test - Statistics Solutions. (2016). Statistics Solutions. Retrieved 31 July 2016, from http://www.statisticssolutions.com/manova-analysis-paired-sample-t-test/*

~~30.~~31. *Perz, S. (2003). Social determinants and Land Use Correlates of agricultural technology adoption in forest frontier: A case study in the Brazilian Amazon. Human Ecology 31, 133-163.*

~~31.~~32. *Petersen, L. & Roy, A. (1985). Religiosity, Anxiety, and Meaning and Purpose: Religion's Consequences for Psychological Well-Being.* Review Of Religious Research*,* 27*(1), 49. http://dx.doi.org/10.2307/3511937*

~~32.~~33. Religion in Uganda*. (2016).* Wikipedia*. Retrieved 8 August 2016, from https://en.wikipedia.org/wiki/Religion_in_Uganda*

~~33.~~34. *Riley, S. (2016). Identifying Barriers to Progress among Farmer Field School Participants in Nwoya, Uganda.*

~~34.~~35. *Somda, J., Nianogo, A. J., Nassa, S., & Sanou, S. (2002). Soil fertility management and socio-economic factors in crop-livestock systems in Burkina Faso: a case study of composting technology. Ecological economics,43(2), 175-183.*

~~35.~~36. Tenge, A. J., De Graaff, J., & Hella, J. P. (2004). Social and economic factors affecting the adoption of soil and water conservation in West Usambara highlands, Tanzania. *Land Degradation & Development*, *15*(2), 99-114.

~~36.~~37. The World Factbook — Central Intelligence Agency*. (2016).* Cia.gov*. Retrieved 28 October 2016, from https://www.cia.gov/library/publications/the-world-factbook/geos/ug.html*

~~37.~~38. *Tizale, C. Y. (2007). The dynamics of soil degradation and incentives for optimal management in the Central Highlands of Ethiopia (Doctoral dissertation, University of Pretoria).*

~~38.~~39. Total livestock population (TLU) (2005) | HarvestChoice*. (2016).* Harvestchoice.org*. Retrieved 12 October 2016, from https://harvestchoice.org/maps/total-livestock-population-tlu-2005*

~~39.~~40. Tscharntke, T., Clough, Y., Wanger, T. C., Jackson, L., Motzke, I., Perfecto, I., ... & Whitbread, A. (2012). Global food security, biodiversity conservation and the future of agricultural intensification. *Biological conservation*, *151*(1), 53-59.

~~40.~~41. Uganda Poverty Status Report 2014 launched*. (2014).* UNDP in Uganda*. Retrieved 21 August 2016, from http://www.ug.undp.org/content/uganda/en/home/presscenter/articles/2014/12/08/uganda-poverty-status-report-2014-launched.html*

~~41.~~42. West Nile | Nile Care. (2016). Nilecareinc.org*. Retrieved 28 November 2016*, from *http://nilecareinc.org/?page_id=60*

~~42.~~43. *wfp.org., (2013).* Comprehensive Food Security and Vulnerability Analysis(CFSVA) Uganda*. Retrieved 1 March 2016, from http://documents.wfp.org/stellent/groups/public/documents/ena/wfp256989.pdf*

Appendix 1 Data cleaning details

- Select treatment group data from the end-line survey database base on the document farmers who participated in the HH survey and also benefits from AS4Y project. And the rest in the end-line survey database is the control group without AS4Y project intervention.
- Select treatment group data from the baseline database.
- Choose the variables that related to the study.
- Crop names standardized “peas” from “Green peas”, “potatoes” from “Irish potatoes”
- In the crop column of baseline data, changed “Fallowing “to “NA”.
- Technology adoption: for the grade 3,4,5 change to 1 which means adopted this technology, for the grade 1,2, changing to 0 which means didn’t adopt this technology.
- Adebo Dominic : In plot1cropB , changed “gnuts,maize” to “maize”
- For the calculation of labour cost. Mainly based on the sum of PotX_labHired . For some HHs who didn't answer the question of PlotX_labhired, but answered the labXC , then we used the answer of the sum of labXC for labor cost.
- In the baseline, Ajonye Mary on-farm consumed for plot 3 is 36500 changed to 3650
- Delet the household Anziku Cosmas for FS ratio calculation which is without the number of production and farm consumption.
- For the FS calculation delet Adrole Kasto without the HH size and farm size, Taibo Fatum without hh size,Idoru Moses without ,Olima Joseph ,Alumai Nobert ,Ocaki Donanto ,Lucy Oranya ,Javuru Edward , Ayomirwoth Beatrice ,Suzan Dradue , Ongwech Ocukune witout Household size.
- Delete Didi Benson with 38 hhAgeF3 and Ashia Mary with 30 hhAgeF3 for the calculation because of unusual number of the age of household number distribution.

Appendix 2 The results of Paired Sample T-test and Multiple Regression Analysis

Table 2.1 The results of Paired Sample T-test of FS ratio before and after AS4Y intervention for the treatment group

```
        Paired t-test

data:  data_AS4Y$FSratio_end and data_AS4Y$FSratio_base
t = -2.9356, df = 111, p-value = 0.004047
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -4.3833008 -0.8504492
sample estimates:
mean of the differences
              -2.616875
```

```
        Paired t-test

data:  data_AS4Y$FSratio_end and data_AS4Y$FSratio_base
t = -1.8033, df = 111, p-value = 0.07405
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -3.3338012  0.1570155
sample estimates:
mean of the differences
              -1.588393
```

Table 2.2 The results of Paired Sample T-test of FSS ratio before and after AS4Y intervention for the treatment group

```
        Paired t-test

data:  data_AS4Y$FSSratio_end and data_AS4Y$FSSratio_base
t = 1.7219, df = 111, p-value = 0.08786
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.07516937  1.07231223
sample estimates:
mean of the differences
              0.4985714
```

```
        Paired t-test

data:  data_AS4Y$FSSratio_end and data_AS4Y$FSSratio_base
t = 3.0661, df = 111, p-value = 0.002724
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 0.4122823 1.9187891
sample estimates:
mean of the differences
               1.165536
```

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Table 2.3 The results of paired sample T test of FS ratio for control group

```
        Paired t-test

data:  data_Control$FSratio_end and data_Control$FSratio_base
t = -1.4129, df = 295, p-value = 0.1587
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -2.5777769  0.4232499
sample estimates:
mean of the differences
              -1.077264
```

Table 2.4 The results of paired sample T test of FSS ratio for control group

```
        Paired t-test

data:  data_Control$FSSratio_end and data_Control$FSSratio_base
t = 2.7985, df = 295, p-value = 0.005473
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 0.5386469 3.0917585
sample estimates:
mean of the differences
               1.815203
```

Table 2.5 Factors influencing the absolute FS ratio in the end-line survey for the control group

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```
Call:
lm(formula = data_Control$FSratio_end ~ Hhsize + FarmSize + stopCrop_num +
    startCrop_num + cropLessArea_num + cropMoreArea_num + UseTech +
    att_optimistic + att_religious + att_positive + att_escape +
    att_trapped + HHH_gender + TLU, data = data_Control)

Residuals:
    Min      1Q  Median      3Q     Max
-10.789  -3.223  -1.074   0.672 111.468

Coefficients:
                 Estimate Std. Error t value Pr(>|t|)
(Intercept)       5.85544    4.94651   1.184   0.2377
Hhsize           -0.06112    0.15072  -0.405   0.6855
FarmSize          0.36302    0.41405   0.877   0.3815
stopCrop_num     -0.16166    0.90067  -0.179   0.8577
startCrop_num     1.98802    0.81532   2.438   0.0155 *
cropLessArea_num -2.67164    1.60304  -1.667   0.0969 .
cropMoreArea_num -0.17240    1.06222  -0.162   0.8712
UseTech          -2.23933    1.45611  -1.538   0.1254
att_optimistic    0.19170    0.82213   0.233   0.8158
att_religious     0.65735    0.56381   1.166   0.2448
att_positive     -0.75176    0.79013  -0.951   0.3424
att_escape       -0.06533    0.62177  -0.105   0.9164
att_trapped      -0.53587    0.48194  -1.112   0.2673
HHH_gender       -2.67591    1.54524  -1.732   0.0846 .
TLU               0.13919    0.20608   0.675   0.5001
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 10.45 on 233 degrees of freedom
  (49 observations deleted due to missingness)
Multiple R-squared:  0.09198,	Adjusted R-squared:  0.03742
F-statistic: 1.686 on 14 and 233 DF,  p-value: 0.05943
```

Table 2.6 Factors influencing the absolute FS ratio in the end-line survey for the control group

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```
Call:
lm(formula = data_Control$FSSratio_end ~ Hhsize + FarmSize +
    stopCrop_num + startCrop_num + cropLessArea_num + cropMoreArea_num +
    UseTech + att_optimistic + att_religious + att_positive +
    att_escape + att_trapped + HHH_gender + TLU, data = data_Control)

Residuals:
    Min      1Q  Median      3Q     Max
-10.783  -3.212  -1.079   0.675 111.476

Coefficients:
                 Estimate Std. Error t value Pr(>|t|)
(Intercept)       5.81036    4.94651   1.175   0.2413
Hhsize           -0.05928    0.15073  -0.393   0.6944
FarmSize          0.36285    0.41405   0.876   0.3817
stopCrop_num     -0.16001    0.90067  -0.178   0.8591
startCrop_num     1.98575    0.81532   2.436   0.0156 *
cropLessArea_num -2.66640    1.60304  -1.663   0.0976 .
cropMoreArea_num -0.17427    1.06222  -0.164   0.8698
UseTech          -2.23939    1.45611  -1.538   0.1254
att_optimistic    0.19170    0.82213   0.233   0.8158
att_religious     0.65599    0.56381   1.163   0.2458
att_positive     -0.75038    0.79013  -0.950   0.3433
att_escape       -0.06278    0.62178  -0.101   0.9197
att_trapped      -0.53474    0.48194  -1.110   0.2683
HHH_gender       -2.67776    1.54524  -1.733   0.0844 .
TLU               0.13897    0.20608   0.674   0.5008
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 10.45 on 233 degrees of freedom
  (49 observations deleted due to missingness)
Multiple R-squared:  0.0918,	Adjusted R-squared:  0.03723
F-statistic: 1.682 on 14 and 233 DF,  p-value: 0.06019
```

Table 2.7 The factors influence the progress of FSS ration in the female-headed group

```
Call:
lm(formula = dataF$FSSratio_gain ~ Project + Hhsize + FarmSize +
    stopCrop_num + startCrop_num + cropLessArea_num + cropMoreArea_num +
    UseTech + att_optimistic + att_religious + att_positive +
    att_escape + att_trapped + HHH_gender + TLU, data = dataF)

Residuals:
    Min      1Q  Median      3Q     Max
-15.967  -5.036  -1.181   2.098  55.517

Coefficients: (1 not defined because of singularities)
                 Estimate Std. Error t value Pr(>|t|)
(Intercept)       4.33517    8.02779   0.540  0.59066
Project          -5.66470    2.73097  -2.074  0.04123 *
Hhsize           -0.02008    0.21987  -0.091  0.92744
FarmSize         -0.17600    0.96624  -0.182  0.85592
stopCrop_num     -0.19450    1.61384  -0.121  0.90437
startCrop_num     3.97945    1.43161   2.780  0.00676 **
cropLessArea_num -1.66299    2.25227  -0.738  0.46243
cropMoreArea_num -4.50761    2.07726  -2.170  0.03294 *
UseTech          -3.69455    2.30041  -1.606  0.11216
att_optimistic    0.40373    1.45518   0.277  0.78215
att_religious     1.48552    0.89481   1.660  0.10075
att_positive      0.23641    1.49522   0.158  0.87476
att_escape       -0.71858    0.96022  -0.748  0.45642
att_trapped      -2.51744    0.79955  -3.149  0.00230 **
HHH_gender             NA         NA      NA       NA
TLU               1.02748    0.61613   1.668  0.09925 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 9.987 on 81 degrees of freedom
  (13 observations deleted due to missingness)
Multiple R-squared:  0.2429,    Adjusted R-squared:  0.1121
F-statistic: 1.856 on 14 and 81 DF,  p-value: 0.04399
```

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Table 2.8 Factors influence the FS ration in the female-headed group

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```
Call:
lm(formula = dataF$FSratio_gain ~ Project + Hhsize + FarmSize +
    stopCrop_num + startCrop_num + cropLessArea_num + cropMoreArea_num +
    UseTech + att_optimistic + att_religious + att_positive +
    att_escape + att_trapped + TLU, data = dataF)

Residuals:
    Min      1Q  Median      3Q     Max
-18.096  -4.998  -1.441   2.747  54.431

Coefficients:
                 Estimate Std. Error t value Pr(>|t|)
(Intercept)       2.22273    8.26731   0.269 0.788722
Project          -5.33741    2.81245  -1.898 0.061288 .
Hhsize           -0.01589    0.22643  -0.070 0.944225
FarmSize         -0.18163    0.99507  -0.183 0.855622
stopCrop_num     -0.31273    1.66199  -0.188 0.851219
startCrop_num     3.75899    1.47433   2.550 0.012669 *
cropLessArea_num -2.06891    2.31947  -0.892 0.375048
cropMoreArea_num -4.63296    2.13924  -2.166 0.033275 *
UseTech          -3.93172    2.36904  -1.660 0.100858
att_optimistic    1.02672    1.49860   0.685 0.495227
att_religious     1.40674    0.92151   1.527 0.130767
att_positive     -0.05274    1.53984  -0.034 0.972761
att_escape       -0.73922    0.98887  -0.748 0.456900
att_trapped      -3.21362    0.82341  -3.903 0.000196 ***
TLU               1.23820    0.63451   1.951 0.054463 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 10.29 on 81 degrees of freedom
  (13 observations deleted due to missingness)
Multiple R-squared:  0.2746,	Adjusted R-squared:  0.1493
F-statistic: 2.191 on 14 and 81 DF,  p-value: 0.01488
```

Table 2.9 Factors influence the FSS ration in the male-headed group

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```
Call:
lm(formula = dataM$FSSratio_gain ~ Project + Hhsize + FarmSize +
    stopCrop_num + startCrop_num + cropLessArea_num + cropMoreArea_num +
    UseTech + att_optimistic + att_religious + att_positive +
    att_escape + att_trapped + TLU, data = dataM)

Residuals:
    Min      1Q  Median      3Q     Max
-49.344  -2.126  -0.686   1.109 112.382

Coefficients:
                 Estimate Std. Error t value Pr(>|t|)
(Intercept)       6.57343    4.57908   1.436   0.1524
Project          -1.03257    1.37930  -0.749   0.4548
Hhsize           -0.12239    0.15857  -0.772   0.4410
FarmSize          0.33402    0.33707   0.991   0.3227
stopCrop_num     -0.07039    0.80466  -0.087   0.9304
startCrop_num     0.77554    0.73877   1.050   0.2949
cropLessArea_num -1.08911    1.22839  -0.887   0.3762
cropMoreArea_num  0.71028    0.89392   0.795   0.4276
UseTech          -2.31782    1.31017  -1.769   0.0781 .
att_optimistic   -0.17509    0.78493  -0.223   0.8237
att_religious     0.41458    0.51375   0.807   0.4205
att_positive     -1.66664    0.67794  -2.458   0.0147 *
att_escape        0.17204    0.55716   0.309   0.7578
att_trapped      -0.10729    0.44073  -0.243   0.8079
TLU               0.13260    0.18249   0.727   0.4682
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 9.129 on 241 degrees of freedom
  (43 observations deleted due to missingness)
Multiple R-squared:  0.06882,	Adjusted R-squared:  0.01472
F-statistic: 1.272 on 14 and 241 DF,  p-value: 0.2253
```

Table 2.10 Factors influence the FS ration in the male-headed group

```
Call:
lm(formula = dataM$FSratio_gain ~ Project + Hhsize + FarmSize +
    stopCrop_num + startCrop_num + cropLessArea_num + cropMoreArea_num +
    UseTech + att_optimistic + att_religious + att_positive +
    att_escape + att_trapped + TLU, data = dataM)

Residuals:
    Min      1Q  Median      3Q     Max
-85.175  -2.093   0.841   3.087 112.326

Coefficients:
                 Estimate Std. Error t value Pr(>|t|)
(Intercept)       9.45218    6.27754   1.506  0.13345
Project          -2.48848    1.89091  -1.316  0.18942
Hhsize           -0.02141    0.21739  -0.098  0.92163
FarmSize          0.38126    0.46210   0.825  0.41016
stopCrop_num     -0.10661    1.10313  -0.097  0.92309
startCrop_num     0.31466    1.01279   0.311  0.75631
cropLessArea_num  0.76792    1.68402   0.456  0.64880
cropMoreArea_num  0.61311    1.22550   0.500  0.61733
UseTech          -3.49117    1.79614  -1.944  0.05309 .
att_optimistic   -0.38220    1.07608  -0.355  0.72277
att_religious     0.28826    0.70431   0.409  0.68270
att_positive     -2.49405    0.92940  -2.683  0.00779 **
att_escape        0.29435    0.76382   0.385  0.70031
att_trapped      -1.27521    0.60420  -2.111  0.03584 *
TLU               0.14929    0.25019   0.597  0.55127
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 12.52 on 241 degrees of freedom
  (43 observations deleted due to missingness)
Multiple R-squared:  0.09668,	Adjusted R-squared:  0.0442
F-statistic: 1.842 on 14 and 241 DF,  p-value: 0.03354
```

Table 2.11 The results of paired sample T test of cassava yield for treatment group

```
	Paired t-test

data:  data_AS4Y$cassaveYield and data_AS4Y$cassaveYield.base
t = -1.033, df = 83, p-value = 0.3046
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -1719.4596   543.9587
sample estimates:
mean of the differences
              -587.7505
```

Table 2.12 The results of paired sample T test of cassava yield for control group

```
	Paired t-test

data:  data_Control$cassaveYield and data_Control$cassaveYield.base
t = 0.64517, df = 250, p-value = 0.5194
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -309.5838  611.2229
sample estimates:
mean of the differences
               150.8196
```

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Table 2.13 The results of paired sample T test of cassava yield for the farmer applied technology adaptation

```
        Paired t-test

data:  Usetech$cassaveYield and Usetech$cassaveYield.base
t = 1.1084, df = 126, p-value = 0.2698
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -115.6077  410.0157
sample estimates:
mean of the differences
                147.204
```

Table 2.14 The results of paired sample T test of cassava yield for the farmer who didn't apply technology adaptation

```
        Paired t-test

data:  NoUsetech$cassaveYield and NoUsetech$cassaveYield.base
t = -0.44304, df = 206, p-value = 0.6582
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -861.2133  545.1724
sample estimates:
mean of the differences
              -158.0205
```

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Appendix 3 Relevant technologies trained to farmers in the AS4Y project and summary of the specific interventions that the farmers were trained in

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Table 3.1 Challenges, opportunities and technologies interventions in each district of AS4Y project

District	Production and marketing challenges	Opportunities	Technology interventions
Arua	- High cost of labour - Low crop productivity - Pests and diseases - Low soil fertility - Storage pests and diseases, - Unreliable weather pattern and drought - Limited access to agro inputs - Land fragmentation	- Diversified sources of income - Access to extension - Access to market - Availability of land - Potential of credit	- Good agronomic practices (GAP) - Integrated pest management (IPM) - Climate change adaptation (Climate smart Agriculture) - Gender awareness and mainstreaming - Soil conservation and fertility management - Promoting commercialization of agriculture - Introduction on the importance of livestock in nutrient management
Koboko	- High cost of labour - Low crop productivity - Pests and diseases (in field and in storage) - Poor storage facilities - Low soil fertility	- Large farms approx. 4.02 acres - Diversified sources of income - High returns to labour - Market access	- Post-harvest handling - Integration of livestock and crop farming - Good agronomic practices (GAP) - Integrated pest management - Gender awareness and

		- Higher rate of fertilizer use (10%) compared to other districts - Access to extension - Potential of credit	mainstreaming
Moyo	- Scattered plots with up to one hour walking distance from home - Low land productivity due to soil infertility - Lowest returns to labour - High cost of labour due to labour scarcity - Droughts, - Poor quality seeds and limited access to other agro-inputs - Weeds	- Higher prices of commodities - Oxen use for crop production (35%) - Access to extension - Availability of land - Potential of credit	- Soil fertility management - Good agronomic practices (GAP) - Integrated pest management (IPM) - Climate change adaptation - Gender awareness and mainstreaming - Introduction of livestock in nutrient management
Nebbi	- High cost of labour - Low crop productivity - Droughts, soil infertility, poor quality seed - Storage pests and diseases - Poor storage facilities	- Relatively large farm size approximately 4.76 acres - Access to extension - Potential of credit - Availability of market - Availability of land	- Post-harvest handling - Good agronomic practices - Integrated soil fertility and pest management - Labour saving technologies - **Gender awareness and mainstreaming** - Integrated nutrient management
Zombo	- High cost of labour - Low crop productivity - Limited land for production - Weeds - Pests and diseases - Droughts, - Soil infertility and - Poor quality seed - Land fragmentation	- Suitability of soils and terrain for production of recommended crops - High returns to labour - Access to extension - Potential of credit	- GAPS - Integrated fertility and pest management - Agricultural information - Climate change adaptation - Gender awareness and mainstreaming - Conservation practices especially for coffee and banana - Integrated nutrient management

Table 3.2 Summary of the specific interventions that the farmers were trained in.

Intervention	Specific practices
Good Agronomic Practices (GAP)	Planting in rows Proper spacing Planting seeds instead of grains Timely planting Soil and water conservation practices Fertilizer application methods Timely and proper weed management Timely and proper pest and disease management Timely and proper harvesting
Integrated Pest Management (IPM)/disease management	Use of pesticides Application of local pest control methods

	Use of tolerant/resistant/improved varieties Use of fungicide
Climate Smart Agriculture practices	Early planting Zero tillage (use of herbicide) Tolerant varieties/crops Soil cover (mulching/use of cover crops) Minimizing/avoiding practices that lead to destruction of organic matter such as bush burning Tree planting Use of irrigation (at the farmers resource centers and with selected farmers and youth) Organic farming practice methods (use of green manures, liquid fertilizers, organic pesticides)
Soil conservation and fertility management	Use of bio fertilizers (Rhizobia) Use of compost manure Use of fertilizers Conservation agriculture Use of stone bands Mulching Use of liquid fertilizers

Appendix 4 R code

1. Load the Package you need

````
```{r message=FALSE}
library(ggplot2) # for plot
library(plyr)    # tools for splitting,applying and combining data
library(dplyr)   # a grammer for data manipulation
library(grid)     # grid graph package
library(tidyr)    # tidy data
library(psych)
```
````

2. Set working directory from which files are loaded.

````
```{r}
setwd("/Users/wenlusha/Documents/R")
```
````

3. Read data

````
```{r}
data= read.csv2("clean1.1.csv")

```
````

4.# Caluculate the attitude score and gain in FS and FSS ratios

````
```{r}
dataatt=mutate(data,att_positive=(att3+att5)/2,att_escape=(att4+att7)/2)
myatt=names(dataatt)%in%c("att3","att4","att5","att7","X")
dataatt=dataatt[!myatt]
colnames(dataatt)[12:14]=c("att_optimistic","att_religious","att_trapped")
data=mutate(dataatt,FSratio_gain=FSratio_end-FSratio_base)
````
````

data=mutate(dataatt,FSSratio_gain=FSSratio_end-FSSratio_base)

```

5. Subset the control and treatment group,male and female household head group

```{r}
data_AS4Y = subset(data,data$Project =="1")
data_Control=subset(data,data$Project =="0")
F=subset(data,HHH_gender =="0")
M=subset(data,HHH_gender =="1")
```

Part 1 Descriptive results

```{r}
#Whole sample group
describe(data$Hhsize)
describe(data$Hhsize_base)
describe(data$TLU)
describe(data$TLU_base)
describe(data$FarmSize)
describe(data$FarmSize_base)
#Control group
describe(data_Control$Hhsize)
describe(data_Control$Hhsize_base)
describe(data_Control$TLU)
describe(data_Control$TLU_base)
describe(data_Control$FarmSize)
describe(data_Control$FarmSize_base)
#Treatment group
describe(data_AS4Y$Hhsize)
describe(data_AS4Y$Hhsize_base)
describe(data_AS4Y$TLU)
describe(data_AS4Y$TLU_base)
describe(data_AS4Y$FarmSize)
describe(data_AS4Y$FarmSize_base)
```

Part 2 : Paired Sample T test

```{r}
t.test(data_AS4Y$FSratio_end,data_AS4Y$FSratio_base,paired=TRUE)
t.test(data_AS4Y$FSSratio_end,data_AS4Y$FSratio_base,paired=TRUE)
```

Part 3 :Multiple regression analysis

```{r}

R=lm(data_AS4Y$FSratio_end ~ Hhsize + FarmSize+ stopCrop_num+startCrop_num
     +cropLessArea_num+cropMoreArea_num+UseTech+
      att_optimistic+att_religious+att_positive+att_escape+att_trapped+
       HHH_gender+TLU, data=data_AS4Y)
print(summary(R))

R.FSS=lm(data_AS4Y$FSSratio_end ~ Hhsize + FarmSize+ stopCrop_num+startCrop_num
    +cropLessArea_num+cropMoreArea_num+UseTech+
    +att_optimistic+att_religious+att_positive+att_escape+att_trapped+
     HHH_gender+TLU, data=dataAS4Y.FSS)
print(summary(R.FSS))

##Figure 7a,7b
```
```

```
R_FS=lm (data$FSratio_gain ~ Project+Hhsize + FarmSize+ stopCrop_num+startCrop_num
 +cropLessArea_num+cropMoreArea_num+UseTech
    +att_optimistic+att_religious+att_positive+att_escape+att_trapped+HHH_gender+TLU,data=data)
print(summary(R_FS))
R_FSS=lm(data$FSSratio_gain ~ Project+Hhsize + FarmSize+ stopCrop_num+startCrop_num
      +cropLessArea_num+cropMoreArea_num+UseTech
      +att_optimistic+att_religious+att_positive+att_escape+att_trapped+HHH_gender+TLU,data=data)
print(summary(R_FSS))
```

Part 4: Logistic multiple regression analysis

```
```{r}
dataR= subset(data,select=c(UseTech,Project,Hhsize,FarmSize,stopCrop_num,startCrop_num,
                    cropMoreArea_num,cropLessArea_num,att_optimistic,
                 att_religious,att_positive,att_escape,att_trapped,FSratio_base,
                 FSSratio_base,HHH_gender,TLU))
data.omit=na.omit(dataR)

#final model
model.final=glm(UseTech~Project+Hhsize+FarmSize+stopCrop_num+startCrop_num+
            cropMoreArea_num+cropLessArea_num+att_optimistic+att_religious+att_positive+
            att_escape+att_trapped+FSratio_base+HHH_gender+TLU,data=dataR,family=binomial(link =
"logit"), na.action (na.omit))
summary(model.final)

        ```
```

Part 5: cassava yield

```
dataY= read.csv2("AS4Y.yield.csv")
#_____AS4Y endline yield
#cassava production
dataY$p1Ac=ifelse(dataY$plot1_cropA=="Cassava",dataY$prod1A.kg.,0)
dataY$p1Bc=ifelse(dataY$plot1_cropB=="Cassava",dataY$prod1B.kg.,0)
dataY$p2Ac=ifelse(dataY$plot2_cropA=="Cassava",dataY$prod2A.kg.,0)
dataY$p2Bc=ifelse(dataY$plot2_cropB=="Cassava",dataY$prod2B.kg.,0)
dataY$p3Ac=ifelse(dataY$plot3_cropA=="Cassava",dataY$prod3A.kg.,0)
dataY$p3Bc=ifelse(dataY$plot3_cropB=="Cassava",dataY$prod3B.kg.,0)
dataY$p4Ac=ifelse(dataY$plot4_cropA=="Cassava",dataY$prod4A.kg.,0)
dataY$p4Bc=ifelse(dataY$plot4_cropB=="Cassava",dataY$prod4B.kg.,0)
dataY$p5Ac=ifelse(dataY$plot5_cropA=="Cassava",dataY$prod5A.kg.,0)
dataY$p5Bc=ifelse(dataY$plot5_cropB=="Cassava",dataY$prod5B.kg.,0)
#cassava plot
dataY$Area1Ac=ifelse(dataY$plot1_cropA=="Cassava",dataY$plot1,0)
dataY$Area1Bc=ifelse(dataY$plot1_cropB=="Cassava",dataY$plot1,0)
dataY$Area2Ac=ifelse(dataY$plot2_cropA=="Cassava",dataY$plot2,0)
dataY$Area2Bc=ifelse(dataY$plot2_cropB=="Cassava",dataY$plot2,0)
dataY$Area3Ac=ifelse(dataY$plot3_cropA=="Cassava",dataY$plot3,0)
dataY$Area3Bc=ifelse(dataY$plot3_cropB=="Cassava",dataY$plot3,0)
dataY$Area4Ac=ifelse(dataY$plot4_cropA=="Cassava",dataY$plot4,0)
dataY$Area4Bc=ifelse(dataY$plot4_cropB=="Cassava",dataY$plot4,0)
dataY$Area5Ac=ifelse(dataY$plot5_cropA=="Cassava",dataY$plot5,0)
dataY$Area5Bc=ifelse(dataY$plot5_cropB=="Cassava",dataY$plot5,0)

# calculate total production for crop
dataY[is.na(dataY)]=0
attach(dataY)
dataY$cassaveYield=(p1Ac+p1Bc+p2Ac+p2Bc+p3Ac+p3Bc+p4Ac+p4Bc+p5Ac+

p5Bc)/(Area1Ac+Area2Ac+Area3Ac+Area4Ac+Area5Ac+Area1Bc+Area2Bc+Area3Bc+Area4Bc+Area5Bc)
```

Formatted: Normal

```
#_AS4Y baseline yield
dataY2= read.csv2("AS4Ybase.yield.csv")

#cassava production
dataY2$p1Ac=ifelse(dataY2$plot1_cropA=="Cassava",dataY2$prod1A.kg.,0)
dataY2$p1Bc=ifelse(dataY2$plot1_cropB=="Cassava",dataY2$prod1B.kg.,0)
dataY2$p2Ac=ifelse(dataY2$plot2_cropA=="Cassava",dataY2$prod2A.kg.,0)
dataY2$p2Bc=ifelse(dataY2$plot2_cropB=="Cassava",dataY2$prod2B.kg.,0)
dataY2$p3Ac=ifelse(dataY2$plot3_cropA=="Cassava",dataY2$prod3A.kg.,0)
dataY2$p3Bc=ifelse(dataY2$plot3_cropB=="Cassava",dataY2$prod3B.kg.,0)
dataY2$p4Ac=ifelse(dataY2$plot4_cropA=="Cassava",dataY2$prod4A.kg.,0)
dataY2$p4Bc=ifelse(dataY2$plot4_cropB=="Cassava",dataY2$prod4B.kg.,0)
dataY2$p5Ac=ifelse(dataY2$plot5_cropA=="Cassava",dataY2$prod5A.kg.,0)
dataY2$p5Bc=ifelse(dataY2$plot5_cropB=="Cassava",dataY2$prod5B.kg.,0)
#cassava plot
dataY2$Area1Ac=ifelse(dataY2$plot1_cropA=="Cassava",dataY2$plot1,0)
dataY2$Area1Bc=ifelse(dataY2$plot1_cropB=="Cassava",dataY2$plot1,0)
dataY2$Area2Ac=ifelse(dataY2$plot2_cropA=="Cassava",dataY2$plot2,0)
dataY2$Area2Bc=ifelse(dataY2$plot2_cropB=="Cassava",dataY2$plot2,0)
dataY2$Area3Ac=ifelse(dataY2$plot3_cropA=="Cassava",dataY2$plot3,0)
dataY2$Area3Bc=ifelse(dataY2$plot3_cropB=="Cassava",dataY2$plot3,0)
dataY2$Area4Ac=ifelse(dataY2$plot4_cropA=="Cassava",dataY2$plot4,0)
dataY2$Area4Bc=ifelse(dataY2$plot4_cropB=="Cassava",dataY2$plot4,0)
dataY2$Area5Ac=ifelse(dataY2$plot5_cropA=="Cassava",dataY2$plot5,0)
dataY2$Area5Bc=ifelse(dataY2$plot5_cropB=="Cassava",dataY2$plot5,0)
#calculate production
dataY2[is.na(dataY2)]=0
attach(dataY2)
dataY2$cassaveYield.base=(p1Ac+p1Bc+p2Ac+p2Bc+p3Ac+p3Bc+p4Ac+p4Bc+p5Ac+

p5Bc)/(Area1Ac+Area2Ac+Area3Ac+Area4Ac+Area5Ac+Area1Bc+Area2Bc+Area3Bc+Area4Bc+Area5Bc)

#establish dataframe fro AS4Y endline
datayield1=data.frame(Name=dataY$Name,cassaveYield=dataY$cassaveYield)
datayield2=data.frame(Name=dataY2$Name,cassaveYield.base=dataY2$cassaveYield.base)
datayield=rbind(datayield1,datayield2)
datayield=merge(datayield1,datayield2)
datayield$cassava_change=datayield$cassaveYield-datayield$cassaveYield.base
#-----------Control yield
dataControlY=read.csv2("ControlYield.end.csv")
#cassava production
dataControlY$p1Ac=ifelse(dataControlY$plot1_cropA=="Cassava",dataControlY$prod1A.kg.,0)
dataControlY$p1Bc=ifelse(dataControlY$plot1_cropB=="Cassava",dataControlY$prod1B.kg.,0)
dataControlY$p2Ac=ifelse(dataControlY$plot2_cropA=="Cassava",dataControlY$prod2A.kg.,0)
dataControlY$p2Bc=ifelse(dataControlY$plot2_cropB=="Cassava",dataControlY$prod2B.kg.,0)
dataControlY$p3Ac=ifelse(dataControlY$plot3_cropA=="Cassava",dataControlY$prod3A.kg.,0)
dataControlY$p3Bc=ifelse(dataControlY$plot3_cropB=="Cassava",dataControlY$prod3B.kg.,0)
dataControlY$p4Ac=ifelse(dataControlY$plot4_cropA=="Cassava",dataControlY$prod4A.kg.,0)
dataControlY$p4Bc=ifelse(dataControlY$plot4_cropB=="Cassava",dataControlY$prod4B.kg.,0)
dataControlY$p5Ac=ifelse(dataControlY$plot5_cropA=="Cassava",dataControlY$prod5A.kg.,0)
dataControlY$p5Bc=ifelse(dataControlY$plot5_cropB=="Cassava",dataControlY$prod5B.kg.,0)
#cassava plot
dataControlY$Area1Ac=ifelse(dataControlY$plot1_cropA=="Cassava",dataControlY$plot1,0)
dataControlY$Area1Bc=ifelse(dataControlY$plot1_cropB=="Cassava",dataControlY$plot1,0)
dataControlY$Area2Ac=ifelse(dataControlY$plot2_cropA=="Cassava",dataControlY$plot2,0)
dataControlY$Area2Bc=ifelse(dataControlY$plot2_cropB=="Cassava",dataControlY$plot2,0)
dataControlY$Area3Ac=ifelse(dataControlY$plot3_cropA=="Cassava",dataControlY$plot3,0)
dataControlY$Area3Bc=ifelse(dataControlY$plot3_cropB=="Cassava",dataControlY$plot3,0)
dataControlY$Area4Ac=ifelse(dataControlY$plot4_cropA=="Cassava",dataControlY$plot4,0)
```

```
dataControlY$Area4Bc=ifelse(dataControlY$plot4_cropB=="Cassava",dataControlY$plot4,0)
dataControlY$Area5Ac=ifelse(dataControlY$plot5_cropA=="Cassava",dataControlY$plot5,0)
dataControlY$Area5Bc=ifelse(dataControlY$plot5_cropB=="Cassava",dataControlY$plot5,0)
#---calculate production
dataControlY[is.na(dataControlY)]=0
attach(dataControlY)
dataControlY$cassaveYield=(p1Ac+p1Bc+p2Ac+p2Bc+p3Ac+p3Bc+p4Ac+p4Bc+p5Ac+

p5Bc)/(Area1Ac+Area2Ac+Area3Ac+Area4Ac+Area5Ac+Area1Bc+Area2Bc+Area3Bc+Area4Bc+Area5Bc)

#----Control end yield
dataControlY2= read.csv2("Controlbase.yield.csv")
#cassava production
dataControlY2$p1Ac=ifelse(dataControlY2$plot1_cropA=="Cassava",dataControlY2$prod1A.kg.,0)
dataControlY2$p1Bc=ifelse(dataControlY2$plot1_cropB=="Cassava",dataControlY2$prod1B.kg.,0)
dataControlY2$p2Ac=ifelse(dataControlY2$plot2_cropA=="Cassava",dataControlY2$prod2A.kg.,0)
dataControlY2$p2Bc=ifelse(dataControlY2$plot2_cropB=="Cassava",dataControlY2$prod2B.kg.,0)
dataControlY2$p3Ac=ifelse(dataControlY2$plot3_cropA=="Cassava",dataControlY2$prod3A.kg.,0)
dataControlY2$p3Bc=ifelse(dataControlY2$plot3_cropB=="Cassava",dataControlY2$prod3B.kg.,0)
dataControlY2$p4Ac=ifelse(dataControlY2$plot4_cropA=="Cassava",dataControlY2$prod4A.kg.,0)
dataControlY2$p4Bc=ifelse(dataControlY2$plot4_cropB=="Cassava",dataControlY2$prod4B.kg.,0)
dataControlY2$p5Ac=ifelse(dataControlY2$plot5_cropA=="Cassava",dataControlY2$prod5A.kg.,0)
dataControlY2$p5Bc=ifelse(dataControlY2$plot5_cropB=="Cassava",dataControlY2$prod5B.kg.,0)
#cassava plot
dataControlY2$Area1Ac=ifelse(dataControlY2$plot1_cropA=="Cassava",dataControlY2$plot1,0)
dataControlY2$Area1Bc=ifelse(dataControlY2$plot1_cropB=="Cassava",dataControlY2$plot1,0)
dataControlY2$Area2Ac=ifelse(dataControlY2$plot2_cropA=="Cassava",dataControlY2$plot2,0)
dataControlY2$Area2Bc=ifelse(dataControlY2$plot2_cropB=="Cassava",dataControlY2$plot2,0)
dataControlY2$Area3Ac=ifelse(dataControlY2$plot3_cropA=="Cassava",dataControlY2$plot3,0)
dataControlY2$Area3Bc=ifelse(dataControlY2$plot3_cropB=="Cassava",dataControlY2$plot3,0)
dataControlY2$Area4Ac=ifelse(dataControlY2$plot4_cropA=="Cassava",dataControlY2$plot4,0)
dataControlY2$Area4Bc=ifelse(dataControlY2$plot4_cropB=="Cassava",dataControlY2$plot4,0)
dataControlY2$Area5Ac=ifelse(dataControlY2$plot5_cropA=="Cassava",dataControlY2$plot5,0)
dataControlY2$Area5Bc=ifelse(dataControlY2$plot5_cropB=="Cassava",dataControlY2$plot5,0)

#calculate yield kg/acre
dataControlY2[is.na(dataControlY2)]=0
attach(dataControlY2)
dataControlY2$cassaveYield.base=(p1Ac+p1Bc+p2Ac+p2Bc+p3Ac+p3Bc+p4Ac+p4Bc+p5Ac+

p5Bc)/(Area1Ac+Area2Ac+Area3Ac+Area4Ac+Area5Ac+Area1Bc+Area2Bc+Area3Bc+Area4Bc+Area5Bc)

#establish dataframe for control endline
dataCyield1=data.frame(Name=dataControlY$Name,cassaveYield=dataControlY$cassaveYield)
dataCyield2=data.frame(Name=dataControlY2$Name,cassaveYield.base=dataControlY2$cassaveYield.base)
ataCyield=merge(dataCyield1,dataCyield2)
dataCyield$cassava_change=dataCyield$cassaveYield-dataCyield$cassaveYield.base
#create new dataframe
Yield=rbind(datayield,dataCyield)
data=merge(Yield,data,by="Name")

##Add att_positive and att_escape
dataatt=mutate(data,att_positive=(att3+att5)/2,att_escape=(att4+att7)/2)
## drop att3,att5,att4,att7
myatt=names(dataatt)%in%c("att3","att4","att5","att7")
dataatt=dataatt[!myatt]

## change variables' name
colnames(dataatt)[21:23]=c("att_optimistic","att_religious","att_trapped")
data_Control = subset(dataatt,dataatt$Project =="0")
```

```
data_AS4Y = subset(dataatt,dataatt$Project =="1")
#------Paired sample t test for treatment group in cassava yield.
data_AS4Y$cassaveYield.base[which(is.nan(data_AS4Y$cassaveYield.base))]=NA
data_AS4Y$cassaveYield.base[which(is.infinite(data_AS4Y$cassaveYield.base))]=NA
t.test(data_AS4Y$cassaveYield,data_AS4Y$cassaveYield.base,paired=TRUE)
##------Paired sample t test for control group in cassava yield.
data_Control$cassaveYield[which(is.nan(data_Control$cassaveYield))]=NA
data_Control$cassaveYield[which(is.infinite(data_Control$cassaveYield))]=NA
data_Control$cassaveYield.base[which(is.nan(data_Control$cassaveYield.base))]=NA
data_Control$cassaveYield.base[which(is.infinite(data_Control$cassaveYield.base))]=NA
t.test(data_Control$cassaveYield,data_Control$cassaveYield.base,paired=TRUE)

#----paired sample t test for technology use
Usetech=subset(dataatt,dataatt$UseTech=="1")
NoUsetech=subset(dataatt,dataatt$UseTech=="0")
Usetech$cassaveYield[which(is.nan(Usetech$cassaveYield))]=NA
Usetech$cassaveYield[which(is.infinite(Usetech$cassaveYield))]=NA
Usetech$cassaveYield.base[which(is.nan(Usetech$cassaveYield.base))]=NA
Usetech$cassaveYield.base[which(is.infinite(Usetech$cassaveYield.base))]=NA
t.test(Usetech$cassaveYield,Usetech$cassaveYield.base,paired=TRUE)
#--- paired sample t test for no technology use
NoUsetech$cassaveYield[which(is.nan(NoUsetech$cassaveYield))]=NA
NoUsetech$cassaveYield[which(is.infinite(NoUsetech$cassaveYield))]=NA
NoUsetech$cassaveYield.base[which(is.nan(NoUsetech$cassaveYield.base))]=NA
NoUsetech$cassaveYield.base[which(is.infinite(NoUsetech$cassaveYield.base))]=NA
t.test(NoUsetech$cassaveYield,NoUsetech$cassaveYield.base,paired=TRUE)
```

Appendix 5 End survey questionnaire of AS4Y project

Section 1: Introduction

1.1. **enumerator**:

1.2. **date**:

1.3. **time**:

Section 2: Household Identification

2.1. **district**:

2.2. **subcounty**:

2.3. **parish**:

2.4. **village**:

2.5. **name**:

2.6. **telephone**:

2.7. **sex**:

2.8. **age**:

Section 3: Farming system

3.1.1 How much land do you cultivate (acres)?

3.1.2 How much land do you own?

3.1.3 How much land do you rent out?

3.1.4 How much land do you rent?

3.1.3 How many plots do you have? max = 10

3.2. Farm description

For each plot (number = X) ask the following questions:

	3.2.1What is the size of plot ? **(acres)**	3.2.2 What is the walking distance to homestead in **minutes**?	3.2.3 Who is the user of the plot? 1 = self; 2 = household member	3.2.4 What is the main crop grown?	3.2.5 What is the dominant intercrop grown?
Plot 1					
Plot 2					
Plot 3					
Plot 4					

For each crop c1/c2 on each plot (X) ask the following questions:

Questions	Plot1		Plot 2		Plot 3		Plot4	
	Main	Dominant	Main	Dominant	Main	Dominant	Main	Dominant

	crop	intercrop	crop	intercrop	crop	intercrop	crop	intercrop
3.2.6 What is the planting method used? (1 = line/row; 2 = broadcasting; 3 = other (*specify*)								
3.2.7. What is the seed rate?(with **unit**)								
3.2.8. Who manages the crop? 1=household head;2=spouse;3=children;4=other(specify)								
3.2.9. Who decides on crop choice? *1=household head;2=spouse;3=children;4=other(specify)*								
3.2.10. Who decides on crop sale? *1=household head;2=spouse;3=children;4=other(specify)*								
3.2.11. Who decides on cash utilization? 1=household head;2=spouse;3=children;4=other(specify)								
3.2.12. What is the key constraint to yield? 1= Diseases; 2 = Pests; 3 = Droughts; 4 = Soil infertility; 5 = Poor quality of seeds/planting materials, 6 = Weeds; 7 = Others (specify); 8= none								
3.2.13 What is the yield **per year (kg)** (if more seasons, calculate per year)?								
3.2.14. How much is consumed/used **per year (kg)?**								
3.2.15. How much has been sold (**kg)?**								
3.2.16. Average market price per **kg (UGX**) for last year?								
3.2.17. How much were the hired								

labour costs?								
3.2.18. How many days did your family work on this crop in total (man-days)/acre/year?								
3.2.19. What where the input costs for this crop?								
3.2.20. What is the major objective of the crop?(1 = only for household food; 2 = mainly for food, sell surplus; 3 = equally for food and sale; 4 = mainly for sale; 5= other (specify)								

Section 4: Cropping patterns

4.1.1. Did you stop growing any crops? If yes answer the following questions.

Number of crops	Which crops did you stop growing?	Why did you stop growing this crop?

4.1.2. Did you start growing any crops? If yes answer the following questions**.**

Number of crops	Which crops did you start growing?	Why did you start growing this crop?

4.1.3. Did you reduce area cultivate for any crop? If yes answer the following questions**.**

Number of crops	Which crops did you reduce area cultivated?	Why did you reduce the area cultivated for this crop?

4.1.4. Did you increase area cultivate for any crop? If yes answer the following questions**.**

Number of crops	Which crops did you increase area cultivated?	Why did you increase the area cultivated for this crop?

4.2. What are the most important factors when choosing what to plant or to reduce crops or land area? Rank 3 most important.
Choose **3** factors for each category, there are three variables.(1=most important)

cropStopFactors	**Rank**	**cropStartFactors**	**Rank**	**cropLessAreaFactorsX**	**Rank**	**cropMoreAreaFactorsX**	**Rank 3**
Value of crops (UGX)		Value of crops (UGX)		Value of crops (UGX)		Value of crops (UGX)	
Energy of crops (kcal)		Energy of crops (kcal)		Energy of crops (kcal)		Energy of crops (kcal)	
Market demand		Market demand		Market demand		Market demand	
Household demand		Household demand		Household demand		Household demand	
Labour input		Labour input		Labour input		Labour input	
Productivity		Productivity		Productivity		Productivity	
Availability of seed		Availability of seed		Availability of seed		Availability of seed	
Demand of fertilizer		Demand of fertilizer		Demand of fertilizer		Demand of fertilizer	
Soil		Soil		Soil		Needs good soil	
Price of seed		Price of seed		Price of seed		Price of seed	
Other (*specify*)		Other (*specify*)		Other (*specify*)		Other (*specify*)	

4.3. Livestock production

Names of variables are given in cells.

Type of livestock	**Tick if you have**	**Number**	**Area of plot/acre**
Local cattle			
Improved cattle			
Goats			
Sheep			
Local chicken			
Improved chicken			

Ducks			
Layers (chicken)			
Local pigs			
Improved pigs			
Rabbits			
Other (*specify*)			
Bees (number of hives)			
Ox			
Other (*specify*):			
Other (specify):			

Section 5: Labour

Variable names are given in the cells

Activity	**Which activity (s) is tedious in terms of labour** (1 = yes; 0 = no)	**Do you use personal/family labour(**1 = yes; 0 = no)	**Do you use hired labour? (**1 = yes; 0 = no)	**Cost in cash/acre**
Land clearing				
Planting				
Fertilizer application				
Weeding				
Spraying				
Harvesting				
Conservation structures				
Others (specify)				

Section 6: Income

Variable names are given in the cells

Income source	**Household member involved** (1 = Husband 2 = spouses; 3 = other adults; 4 = children; 5 = other (specify)	**Frequency - time units** (1 = daily; 2 = weekly; 3 = monthly; 4 = seasonally; 5 = quarterly)	**Earning per unit time (UGX)**	**Earnings during the last year (UGX) (*Automatically calculated*)**
Crop trade				
Livestock trade				
Off-farm casual labor				
Food processing				
Permanent off farm				
Petty trading				
Handicrafts				
Pensions				
Remittances from relatives				
Other (*specify*)				
Other (*specify*)				

Section 7: Technologies and constraints

7.1. Have you been trained by other extension services/NGOs in the past three years? Which ones?

7.2. Have you been trained in the following by extension services/NGOs? 1=no 2=yes

gap: Good agronomic practices
ipm: Integrated Pest Management
csa: Climate Smart Agricultural Practices
isfm: Soil conservation and fertility management

7.3. Which technologies have you been using?

The follow-up questions are all free-text questions. When 'observed' is mentioned, this should be observed by the enumerator.
The extent of adoption is rated by the enumerator based on the answers of the farmers and his/her observations.

Code for "Where did you hear about this technology?"
1=television;2=radio;3=newspaper;4=extension staff; 5=fellow farmers(5.1 fellow farmers from AS4Y); 6= NGOs,7=local readers,8=other(specify)
"Barriers to adoption" (v) 1 = Lack of access to agricultural information; 2 = Limited availability and access to improved inputs; 3 = Limited availability and access to labor; 4 = Lack of appropriate technologies for value addition; 5 = Inadequate knowledge and skills, 6 = Few extension agents, 7 = Lack of demonstration farm to learn from, 8 = Lack of exposure (field visits), 9 = Fear for new technologies(taking risks of trials), 10=others(specify), 11=None

Specific practices (tick which ones are used)	**Tick**	**Follow up questions** Names: techRow_1 techRow_2 techSpace_1 techSpace_2		**Extent of adoption, rated by enumerator (i)** 1=very poorly;2=poorly;3=fairly;4=good;5=very well	**Where did you hear about this technology? (ii)**	**Did you share the knowledge? (iii)** (1=no;2=neighbors;3=my HH members;4=farmer group;5=other(specify)	**Usefulness of technology (iv)** (1=not useful;2=useful;3=fairly useful;4=relatively useful;5=very useful)	**Barriers to adoption (v)**
Planting in rows		Observe						
Proper spacing		Observe						
Planting seeds instead of grains		Where did you get your seeds?	What is the difference between seed and grain?					
Timely planting		When did you						

		plant your seeds?						
Timely and proper harvesting		When did you harvest last season?						
Timely and proper weeding (manual, mechanical, chemical)		Observe	How many times did you weed per year? When did you weed?					
Soil cover (mulch, cover crops)		Observe	When?					
Application of local pest control methods		What did you do?	where did you apply it?					
Use of P&D tolerant/resistant/improved		What did you	where did you apply					

varieties		do?	it?					
Use of fungicide		What fungicide did you use?	where did you apply it?					
Use of pesticides		What pesticides did you use?	what crop did you apply to?					
Conservation agriculture (stone bunds, tree lines, trenches, grass trips, zero tillage)		Observe	What conservation measures did you apply?					
No burning of crop residues or bush		Observe	Do you burn crop residues or bush?					
Climate tolerant		For whi	Where did					

varieties/crops		ch crop did you choose the tolerant varities?	you get it? How much?					
Use of irrigation		How did you irrigate your farm?	When and how many times did you irrigate?					
Companion tree planting		Observe	Which trees did you plant?					
Use of chemical fertilizers (dry, liquid)								
Use of organic fertilizers (compost, animal manure, green		Where is your compost	Where do you get manure from.					

manure)		hea p?						
Use of rhizobia		Obs erve	On which crop did you use it? What is the functi on of Rhizo bia?					

7.4. Technological adaptation and impact

* free text questions

7.4.1. Did you change any of the technologies you were trained in order to make them more useful for you? And why?

7.4.2. Were there any other innovations in the society mainly to enable adoption or maximize benefits from the technology (eg shared labor, organization to access inputs, credit, extra knowledge etc)?

7.4.3. Did the adoption of new technologies have any impact on your livelihood (e.g. yield, income, labour, food security, use of farm resources) or the community (e.g. Land distribution, conflict, cooperation, wealth distribution etc)?

7.4.4. Did the adoption of new technologies have any impact on your farming system (pest dynamics, diseases, soil fertility, moisture, erosion, weeds and other on farm activities)?

Section 8: Attitudes

Variable name	**Statement**	1 = strongly disagree, 2 = somewhat disagree, 3 = neutral, 4 = somewhat agree, 5 = strongly agree

att1	I am proud to be a farmer.	
att2	God meant for me to be a farmer.	
att3	There is no better investment than farming.	
att4	If I had a choice I would not be a full time farmer.	
att5	Any farm method that saves me time is worth paying for.	
att6	There is no hope for poor farmers like us.	
att7	I would prefer if my children do not end up working as farmers.	

Section 9: Household characteristics

9.1. **Household type:** 1 = male headed, one wife; 2 = male headed, more than one wife; 3 = female headed, widowed; 4 = female headed, single; 5 = other (*specify*)

9.2. Residence of household head; 0 = non-resident; 1 = resident

9.3. Occupation of respondent; 1 = farming; 2 = commerce; 3 = job with salary; 4 = petty trading; 5 = brewing, 6 = private/artisan 7 = other (*specify*)

9.4. Occupation of spouse; 1 = farming; 2 = commerce; 3 = job with salary; 4 = petty trading; 5 = brewing, 6 = private/artisan 7 = other (*specify*)
* (see 3.1) If widowed or multiple wives, this question should either not be asked or asked for each of the spouses (max 3)

9.5. **education:** Level of education of respondent; 1 = no formal education; 2 = adult education; 3 = primary education; 4 = lower secondary; 5 = upper secondary; 6 = vocational; 7 = tertiary; 8 = other (*specify*)

9.6. **hhAge:** List members of the household and their age and sex
variable name: hhAgeM1 hhAgeM2 hhAgeM2 hhAgeF2

Age category	**0-5 (=1)**		**6-17 (=2)**		**18-59 (=3)**		**>59 (=4)**	
Sex	M	F	M	F	M	F	M	F
Number								

9.7. **childEdu**: What is the level of education of children residing in the household?

Child	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**

Sex											
Level of education											
1 = no formal education; 2 = adult education; 3 = primary; 4 = lower secondary; 5 = upper secondary; 6 = vocational; 7 = tertiary; 8= other (*specify*)											

9.8. **lab**: What is the number of people in your household involved in on-farm and off-farm labour?

* variable names are in the cells.

Age category (years)	**≤15 years (=1)**	**>15 years (=2)**
Male – full time on farm		
Female – full time on farm		
Male – part time on farm		
Female – part time on farm		
Male – off farm		
Female – off farm		