LAND HUSBANDRY, WATER HARVESTING, AND HILLSIDE IRRIGATION PROJECT, RWANDA

IMPACT EVALUATION ENDLINE REPORT

World Bank Development Impact Evaluation Unit

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Contents

List of Tables

List of Figures

1 Executive Summary

The Land Husbandry, Water Harvesting and Hillside Irrigation (LWH) project is a flagship initiative aligned with Rwanda's Ministry of Agriculture and Animal Resources (MINAGRI) sector-wide strategy, and is a key pillar of the World Bank's portfolio in the region. The project emphasizes increased productivity in selected sites through investments in developing terraces, hillside irrigation, combined with the promotion of improved farming technologies and practices. The suite of LWH interventions is integral to MINAGRI's strategy under PSTA-III and PSTA-IV and the goal of transforming the rural economy.

This report presents causal estimates of the *overall* impact of the LWH program. The design, rollout and implementation of this evaluation results from a long-term partnership between the LWH project team (SPIU), MINAGRI, the World Bank's Operational Impact Evaluation (DIME) teams. Over the span of 6 years, the impact evaluation tracked a number of project-related input and outcome indicators. Aligned with the project's development objective and built around core areas of the implementing team's focus, the evaluation sheds light on the overall impact of the program.

Prior to program implementation, during pre-feasibility, the LWH, DIME and the World Bank's Task team designed a prospective impact evaluation to plausibly capture the causal impact of the program. In each phase of implementation, the project targeted a certain number of sites in which to intervene. The impact evaluation tracked outcomes across several sites that were identified during pre-feasibility, including a subset of eligible sites that were left out of program implementation due to budgetary constraints. In other words, of the set of sites that passed pre-feasibility, a number that were otherwise identical to the project sites were not assigned to the LWH intervention offer a good reasonable counter-factual (comparison) to the sites that received the program. This allows the impact evaluation to measure what *would have happened* in the absence of the LWH interventions. Data were collected across the intervention (*treatment*) sites and these *comparison* sites - **implementing a non-experimental matched difference-in-difference strategy to estimate project impact.**

Working together, DIME and the LWH team worked to collect data across approximately 600 households in 1B sites over 6 years, and 5 sets of agricultural seasons. This panel dataset is unique, both in the its length and in the richness of demographic, agricultural and household data it brings together. A dataset of this volume is uncommon in the policy landscape and allows the research team to investigate impacts of a complex program in a way that would have been otherwise impossible. The dataset covers three key sets of indicators that form the focus of analysis: agricultural productivity - the core of LWH's focus; project inputs and delivery mechanisms that influenced agricultural outcomes; and non-agricultural indicators of household welfare.

Households in LWH project sites witness large and statistically significant impacts on agricultural production indicators that can directly be attributed to project interventions. While these these impacts started to materialize in the early phase of the project, they increased in magnitude over the course of the project. The primary indicator of production - value of harvests - is higher for treatment households relative to comparison households across years and seasons. Predictably, the value of harvests in Season A is consistently higher than in Season B. In 2017 Season A, harvest in treatment areas is about 36 % higher than in the comparison areas. The largest effect of the program is in 2017 Season B, when the treatment households' value of harvest is about 60 % more than the comparison group, which harvests RWF 75,000 in this season. In addition, the treatment group has a significantly higher share of its harvests sold in markets - with value of sales and share of agricultural production commercialized both significantly larger for the treatment group relative to the comparison. In 2017 Season A, the effect of LWH on sales value is 50 % more than a comparison group mean of approximately RWF 40,000. In addition, in 2017 Season B, LWH causes an increase in commercialization share of 7 percentage points more, relative to a comparison average of 22 %. Plot-level analysis reveals that the project leads to an increase in productivity - in 2017 treatment households have about 42 % higher net yield relative to the comparison group mean of RWF 330,000. The analysis suggests that when making farming decisions, farmers tend to allocate resources across plots in an efficient way and that the plot is a more appropriate unit of analysis than the household for this set of indicators.

Across the board, households in LWH sites report higher access to services, use of inputs and adoption of technologies. This result holds across seasons and years, as LWH causes a 26 percentage point impact on households likelihood of receiving public extension, relative to a comparison group rate of 9 %. A similar result holds true for access to Tubura services. The adoption of agricultural and land-management technologies including erosion control, fertility management and enhanced productivity is consistently and significantly higher for LWH households than their comparison counterparts. In the case of erosion-control, for example, LWH increases the likelihood of adopting this technology by 60 percentage points in 2018, relative to the comparison group's adoption rate of 50 %.

In terms of non-agricultural outcomes, LWH households outperform comparison households in terms of rural finance and total income, with food security reducing drastically across all surveyed households. Access to banks and savings behavior show significant positive impacts for LWH households relative to comparison households, with LWH causing a 50 % point impact on likelihood of having a bank account, relative to a comparison group mean of 80 %. Food security in 2017 shows drastic improvements over the previous year across the sample. Further analysis of this outcome points at the fact that households' food security status is subject to drastic variation across years. Going against conventional wisdom, analysis shows that food security is a risk for a range of farmers, as many experience significant changes from one year to the next.

Overall, LWH significantly improved farmers lives primary through the channel of increased agricultural productivity. Tracked over the course of 6 years, farmer welfare - as measured both by agricultural and non-agricultural indicators - is higher at endline relative to the pre-program levels. **The Overall Impact Evaluation of the LWH program is an example of how an implementation team can work to learn lessons on program impacts through a non-experimental Impact Evaluation design that relies on natural constraints related to program design and delivery.** The multi-year, rich panel dataset that tracked almost 1000 households across 5 survey rounds points at the government team's commitment to strong data systems and decisions grounded in evidence; and a commitment to learning and improving the program at every stage.

2 Background

Agriculture is a major engine of the Rwandan economy, and remains a priority sector in the Government of Rwanda's goals of reducing poverty and achieving food security through commercialized agriculture (Rwanda Economic Development and Poverty Reduction Strategy). Sustained improvements to agricultural productivity are necessary to achieve this ambitious target, calling for investments in land management, water harvesting, and intensified irrigation of the hillsides. The Land Husbandry, Water Harvesting and Hillside Irrigation (LWH) project has been working to meet these goals.

The LWH uses a modified watershed approach to introduce sustainable land husbandry measures for hillside agriculture on selected sites, and develops hillside irrigation for sub-sections of each site. The project has three components: (1) capacity development and institutional strengthening for hillside development, which aims to develop the capacity of individuals and institutions for improved hillside land husbandry, stronger agricultural value chains, and expanded access to finance; (2) infrastructure for hillside intensification, which provides the essential hardware for hillside intensification to accompany the capacity development of the first component; and (3) implementation through Ministry of Agriculture and Animal Resources (MINAGRI) SWAp (sector wide approach) structure which aims to ensure that project activities are effectively managed within the government program.

2.1 Agricultural Seasons in Rwanda

Rwandan agriculture has traditionally been rainfed, with a small proportion of the country's farmers utilizing irrigation. The World Bank's Project Appraisal Document for the LWH project estimated about 15,000 hectare of irrigated land across the country. Agricultural seasons have historically therefore been strongly dependent on the timing and intensity of rainfall. There are two rainy seasons, and consequently two traditional agricultural seasons. The main agricultural season (or Season A) for a given year lasts from September of that year to February of the next calendar year; and the secondary agricultural season (or Season B) lasts from March and ends in June of the same year. The dry season (or Season C) follows Season B, and lasts from July through September. For the rest of this report, the team refers to the main rainy season as Season A, the secondary rainy season as Season Season B and the dry season as Season C.

2.2 LWH Impact Evaluation

The Development Impact Evaluation (DIME) team's long term relationship with the Government of Rwanda that began in 2011 under the Global Agriculture and Food Security Program (GAFSP) showcases how a government can take a sector-wide approach to impact evaluation. What started as a single GAFSP-financed evaluation project has evolved into a large portfolio of impact evaluation studies in the agricultural sector, driven by MINAGRI's interest to learn from robust evidence.

Evaluating the overall impact of the LWH project allows MINAGRI to effectively plan for its future activities. It aims to operationalize MINAGRIs strategy to encourage monocropping of cash crops, as opposed to the traditional system of inter-cropping for household consumption. The LWH project includes major infrastructure investments such as hillside terracing, irrigation dams, and post-harvest storage. During its appraisal and planning phase, the project aimed to cover an area of 30,250 hectares, ultimately affecting approximately 20 watersheds. The project planned a multi-phased program in which infrastructure and investments were rolled out in different LWH project areas at different times. Each LWH project area is called a 'site' and corresponds to a watershed in a specific valley. A site is divided into three areas, qualified by its position relative to the proposed dam location: command area, water catchment area, and command area catchment. The command area lies downstream from the proposed dam and contains the land to be irrigation. The water catchment area is upstream from the dam, while the command area catchment is the hillsides downstream from the dam but above the command area, which will not receive irrigation[1]. This IE was designed through discussions with the task team and government counterparts - with a goal of covering Phase 1B and 1C sites where the project had been implemented in 2012 and 2013, respectively. For the rest of this report, these project areas are referred to as 1B and 1C sites.

Given the LWH's multi-faceted approach toward enhanced productivity, improved technologies and land management practices, DIME has worked closely with the government team to design an impact evaluation that thoroughly examine both the overall impact of the project as well as the effects of each of its many components. Outcomes such as agricultural productivity, technological adoption, input use, household income, and food security are the areas on which this evaluation study has focused. The list of outcome indicators have evolved over time through intensive periodical dialogs that have included civil society organizations, private stakeholders and relevant government authorities.

Additionally, DIME has worked closely with the government team to design and test elements related to specific sub-components of the LWH project; focusing on areas identified by MINAGRI as priority areas for real-time learning. This included 2 large-scale experiments on innovative savings mechanisms and extension feedback systems have been completed in the last 3 years. In addition, DIME has been engaging with the implementation team on an evaluation of the impacts of irrigation; and strategies to improve horticulture adoption, as well as operation and maintenance of irrigation infrastructure. The results from these experiments have been shared with the project and operational team. They point to large gains in profits as a result of irrigation access, driven almost entirely by the adoption of high-value horticulture. For more details, please refer to the DIME Brief on the *Irrigation Impact Evaluation.*

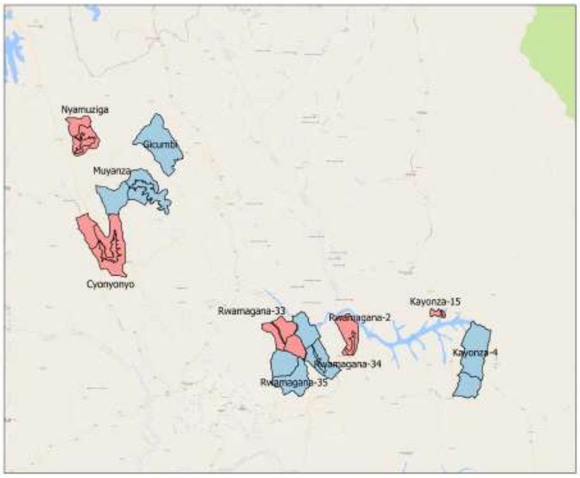
3 Survey and Evaluation Design

This evaluation employed a pair-wise matching of project sites to isolate the project impact from other factors that might influence the outcome indicators of our interest. In order to achieve this, for each site that was selected in two phases of the project, a *comparison* site was identified during the feasibility study and project design stage. The selected comparison sites had geographical, climatic and land-usage characteristics that were similar to the their corresponding treatment sites. This study takes advantage of the similarities between the treatment and comparison sites, and is founded on the assumption that assignment to the LWH project could have been to either site. While this is not a experimental impact evaluation study, it uses the comparison sites as the *counterfactual* in its attempt to isolate the program effects. Due to its quasi-experimental nature, the study uses the term, *comparison* sites or groups, as opposed to *control* sites or groups. The map below (Figure 2) shows the location of the sites that were

[1] For more information: `http://www.gafspfund.org/sites/gafspfund.org/files/Documents/LWH%20Impact%20Evaluation%20Concept%20Note_final.pdf`

selected as treatment and comparison for both the 1B and 1C phases:

Figure 2: Map of Treatment of Comparison Sites



Note: Blue indicates treatment sites, red, comparison sites.

3.1 Key Indicators

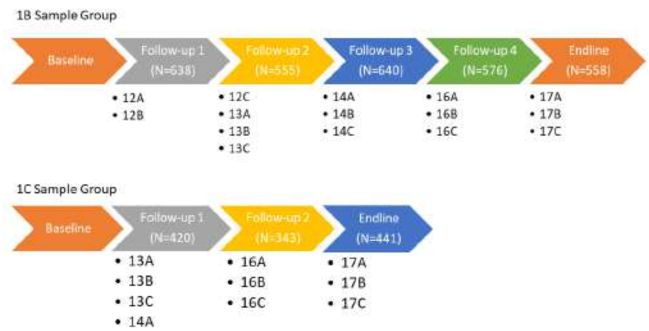
The main indicators of this impact evaluation were chosen based on the LWH's result framework as well as general questions that would help MINAGRI make effective policy decisions. Multi-module agricultural household surveys were used to collect data for calculating the following indicators:

- Access to various forms of extension services
- Adoption of agricultural technologies and improved farming methods
- Use of irrigation
- Crop cultivation decisions
- Total harvests
- Expenditure on inputs
- Total sales
- Non-farm income
- Food consumption and security
- Usage of services from formal financial institutions[2]

3.2 Data Collection

DIME has been working with the LWH operational team to collect seasonal and annual data from a sample of households in the treated and comparison sites since 2012. The following diagrams map out the seasons collected and the number of households interviewed in each survey round for each 1B and 1C sample group.

Figure 3: Data Collection Structure and Panel



Note: N indicates the number of households surveyed.

As shown in Figure 3, the impact evaluation relies on the rich panel dataset. Five surveys have been conducted for the 1B sample group covering six project years, and three follow-up surveys for the 1C sample group over four project years. Each project year is separated into three seasons according to the convention in Rwandan agriculture. Season A or the main rainy season, which lasts from late summer to early spring, Season B, or the secondary rainy season, from early spring to early summer, and Season C, or the dry season, over the course of summer. Historically, the Season A has been the most productive, while Season B and C have tended to be much less fruitful. This tendency is shown in the trend graphs on the key indicators in Appendix B for 1B group and Appendix C for the 1C group. Specifically, the harvest and sales values, and yields are much lower in Season B across project years for both sample groups. As the Dry season relies completely on irrigation, farmers

[2] Note that this is not a list of all questions in the questionnaire. There are multiple questions asked to form each key indicator. Additionally, some indicators have been added later in the evaluation study.

in our sample tend not to plant any crops. Therefore, this study focuses on the two rainy seasons. [3].

It should be noted that households could leave or re-enter into the survey sample. This was for a variety of reasons including the unavailability of respondents due to dissent, emigration, hospitalization, and so forth. Enumerators at each survey round were asked to schedule second or third visit if respondents were temporarily unavailable so as not to affect the sample drastically. Depending on the reasons for not being able to reach a households in a given round, the team re-visited households in subsequent surveys.

3.3 Treatment Definition

As discussed at the beginning of this section, the treatment was originally assigned to households based on their location in a given treatment or comparison site. Based on feedback from the LWH operational team, the GPS location of each cultivated plot was taken during the follow-up 4 and endline surveys. This allowed the research team to know whether a plot that belonged to a treatment household was indeed located in a treatment site. As expected, there were some cases where treatment households cultivated plots in both treatment and comparison sites, and comparison households cultivated in both sites. A household was defined as being treated if any one of its plots fell into the treatment boundary. Only 0.4% of households had plots falling both within and outside the command area; the rest had all their plots on one side of the boundary or the other. The analysis likely did not change drastically as a result of the rule, but the treatment definition is more precise.

Table 1 shows the distribution of treatment and comparison households in each site. Most sites have a mix of households that are classified as treatment and comparison, but each site has a substantial majority of a given type of household.

Table 1: Treatment Definition by Plot Location

Sample	Site Name	Comparison	Treatment
1B	Rwamagana-34	21	463
	Rwamagana-35	76	465
	Kayonza-4	28	418
	Rwamagana-2	413	0
	Rwamagana-33	399	20
	Kayonza-15	497	0
1C	Muyanza	53	178
	Cyonyonyo	357	2
	Gicumbi	6	236
	Nyamuziga	244	0

4 Analytical Setup

4.1 Balance Check

In an impact evaluation study, causality can be credibly claimed when the treatment group is very similar to the comparison group before the program. If this holds true, any differences in outcomes across the groups that is observed after program implementation can be attributed to the program interventions. Irrespective of how this counterfactual is established, it is only as good as the pre-treatment "balance" between the treatment and control groups. Another way of thinking about "balance" is the likeness of the two groups across a range of important indicators. This is measured by statistically comparing the average values of indicators that are relevant to each research question, measured before project implementation. In the present study, a range of household characteristics such as the living conditions, number of dependents, and non seasonal household income, etc. are investigated. These indicators are important since they might plausibly affect the relationship between the project and key outcomes of interest. Key agricultural indicators are also scrutinized here.

[3] This is different from the Irrigation Impact Evaluation that focused specifically on sites that had irrigation schemes through which farmers had access to and utilized water in the dry season

Table 4 statistically compares the treatment and comparison groups in the 1B sample at baseline. For each outcome, the mean and standard error are displayed for the treatment group and the comparison group in columns 1 and 2 respectively. In column 3, the difference between the means is displayed. In addition, a two-sided t-test is used to determine if this difference is statistically distinguishable from zero.

The test for balance indicate that in general, at baseline, 1B treatment and comparison households are comparable across a number of dimensions. Statistically significant differences are observed in the literacy level of household heads, whether households use public tap water as the primary source of drinking water, total sales values, input values, and gross and net yield in Season A. The difference in household heads' literacy and drinking water source is unfortunately quite significant and substantial. Therefore, we control for these variables (along with other household characteristic indicators) in the regression analysis. The difference over the sales and input values, and gross and net yield are not as strongly significant, but large.

On the other hand, the treatment and comparison groups of the 1C sample (presented in Table 31 in Appendix C.2) are less balanced. For a range of agricultural and non-agricultural outcomes including input spending, harvest values, sales values, gross and net yield, as well as crop choice, treatment households are, on average, statistically significantly worse off than comparison households. Although the same method was applied to both the 1B and 1C sites, the balance tables indicate that while understanding and investigating trends in indicators for the 1C sample is useful, making the case for causal impact for the same is challenging. **Therefore, this report focuses on the 1B sample. The data on the 1C sample is still useful, nonetheless, and are presented in Appendix C accompanied by a brief in C.1.**

4.2 Empirical Strategy

This study applies a difference-in-difference estimation strategy to the multi-year panel dataset, and shows the average changes of the treatment group relative to the comparison group. As mentioned in 3.2, the 1B sample offers a rich dataset which contains six project years and captures the seasonal variation across a number of relevant indicators.

The empirical strategy aims to draw out the treatment effect per year. This makes it possible to track the year-on-year transition in the impact of the project on a given outcome variable. The baseline for the 1B sample was in 2012. The results will present the average changes by year for three years: 2013, 2014, 2016, and 2017. As we did not collect data in 2015, the panel has a gap in 2015. The model is represented as

$$y_{it} = \beta T_i + \sum_{l=2013}^{2017} 1(l == t)\gamma_l + \delta_l(T_i) + \theta X_i + u_{it}, \tag{1}$$

where i indexes a given household, t indexes a given year, T is a binary variable indicating treatment status, X is a vector of baseline household-level characteristics that serve as controls and u is a household-level error term.

The treatment effect is the sum of the treatment coefficient, β; the year effect, γ; and the interaction of the year and treatment effect, δ. The model is applied to all indicators. **The following sections graphically present the regression results for the 1B sample. Each graph shows the average values for treatment and comparison households. The results are organized by the outcome categories: agricultural production, project-related inputs, and non-agricultural indicators. The results for the 1C sample are shown in Appendix C.**

One main goal of the model is to tease out a production function for individual farmers, i.e. to understand and isolate the factors that might be important in explaining outcomes of interest. In addition to the year-on-year average impact estimates, we also use a polynomial function to investigate the relationship between outcomes of interest and input use - the promotion of which was a cornerstone of the LWH project. This model is represented as:

$$y_{it} = \beta T_i + \sum_{l=2013}^{2017} 1(l == t)\gamma_l + \delta_l(T_i) + \theta X_i + u_{it}, \tag{2}$$

where the only addition to the previous model is the addition of the cubic term related to inputs. This term allows the team to map the relationship between harvests (for eg.) and inputs across different levels of input use. This is particularly salient for input use, given the wide distributions in households' use of the same.

Figure 4: Balance Table 1 (1B Sites)

Variable	N	(1) Treatment Mean/SE	N	(2) Control Mean/SE	T-test Difference (1)-(2)
Age of the head of the household at the baseline	288	45.378	302	46.775	-1.396
		(0.849)		(0.886)	
Number of dependents at the baseline	289	2.363	302	2.351	0.012
		(0.090)		(0.089)	
If the head of the household was literate at the baseline	289	0.640	302	0.540	0.100**
		(0.028)		(0.029)	
Gender of the head of the household at the baseline	289	0.761	302	0.735	0.026
		(0.025)		(0.025)	
If the household head completed the primary education	289	0.280	300	0.247	0.034
		(0.026)		(0.025)	
Area of the plots the household owned at the baseline	289	0.803	302	1.050	-0.247
		(0.096)		(0.125)	
If public tap is the primary source of water at the baseline	289	0.550	300	0.443	0.107***
		(0.029)		(0.029)	
If paraffin is the main source of light at the baseline	288	0.420	300	0.400	0.020
		(0.029)		(0.028)	
Total income (no seasonal crops)	289	77924.394	300	90131.700	-1.22e+04
		(8603.679)		(9186.041)	
HH moderately or severely food insecure	289	0.059	300	0.090	-0.031
		(0.014)		(0.017)	
Total value of harvests in Season A	289	92001.978	300	80789.929	11212.049
		(5167.738)		(4740.356)	
Total value of sales in Season A	289	35653.395	300	26729.650	8923.745**
		(3149.905)		(2621.008)	
Total spending on inputs in Season A	289	4950.882	300	3758.000	1192.882**
		(432.786)		(359.621)	
Total area cultivated (ha) in Season A	289	0.389	300	0.457	-0.068
		(0.030)		(0.035)	
Gross yield in Season A	197	3.45e+05	223	2.83e+05	62266.417*
		(26522.407)		(21579.408)	
Net yield in Season A	197	3.27e+05	223	2.70e+05	57539.882*
		(25410.513)		(20965.597)	
Total value of harvests in Season B	289	34143.017	300	29491.512	4651.506
		(2584.325)		(2077.782)	
Total value of sales in Season B	289	7602.076	300	6113.937	1488.139
		(1029.174)		(786.905)	
Total spending on inputs in Season B	289	1360.519	300	1177.550	182.969
		(143.998)		(131.601)	
Total area cultivated (ha) in Season B	289	0.277	300	0.340	-0.063
		(0.027)		(0.032)	
Gross yield in Season B	144	1.79e+05	168	1.60e+05	19015.251
		(15243.785)		(13057.355)	
Net yield in Season B	144	1.73e+05	168	1.54e+05	18891.637
		(14725.823)		(12615.682)	

Notes: The value displayed for t-tests are the differences in the means across the groups. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

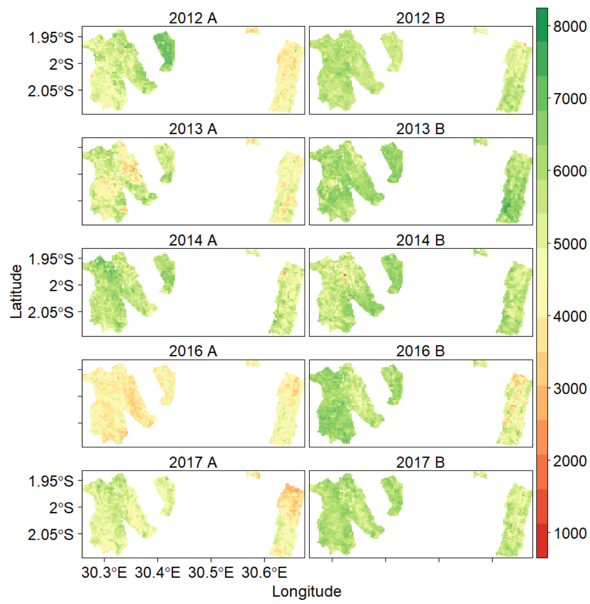
5 Results - 1B Households

In this section, we present results of the impact of the LWH project on a range of outcomes. Given the nature of the interventions, the focus of the analysis is on agricultural outcomes, especially on *production-related* measures - value of harvests, sales and yield. Additionally, we look into *project-related* variables to understand the paths through which the project might have affected agricultural production. These include crop choice, use of agricultural technologies and extension. Regression results, representing estimates of program impacts, based on the specification from Equation 1 in Section 4.2 are visually presented in this section. The trend charts are shown in Appendix B. Lastly, we investigate non-agricultural outcomes including non-seasonal income, food security and financial behavior.

5.1 Agricultural Production

LWH has a statistically significant and positive impact on a number of outcome indicators across years. The trends on most indicators for both treatment and comparison groups generally increase from the baseline level, and the gaps between the groups are statistically significant. The most positive results are seen in the total sales value (Figure 7) and share of commercialization graphs (Figure 8). The project has a positive impact on these indicators across years, including in 2016 during which much of the sample were affected by the drought that struck Eastern Rwanda[4]. Figure 5 shows a head map plotting the normalized deference vegetation index (NDVI) over the 1B sites for each planting period for each of the two rainy season across 2012 and 2017. It clear shows the severity of drought in 2016. While the vegetation index is not same as precipitation data, it is a good proxy indicator that shows climatic and land conditions.

Figure 5: Vegetation in the Sowing Periods Seasons A and B 2012 - 2017

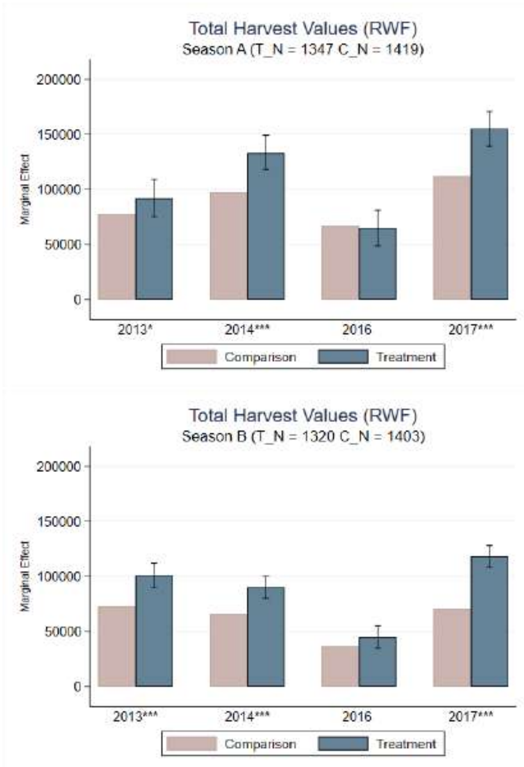


Source: https://lpdaac.usgs.gov/node/844
Notes: Green indicates lusher vegetation, and red means drier. We used the average of the NDVI in September and October for Season A, and February and March for Season B.

Figure 6 presents the impact of LWH on total harvest values for each year for which we collected data, and represents the impact of the program on harvests in each year of the program. Across years, the treatment group's harvest levels are statistically significantly greater than the comparison group. In 2017 Season A, the causal impact of LWH on harvests is 36 %, relative to the comparison group mean of RWF 110,000. **The largest impact of the project is in Season 2017 B, wherein the result points to an impact of 60 % relative to a comparison group mean of RWF 75,000.** This is especially notable given that the harvest values have historically been significantly lower in Season B than Season A. (See Figure 24c for the trend in the total harvest values.)

[4]The World Food Program sent food assistance to Eastern Rwanda in July 2016 due to "unevenly distributed rains result[ing] in below-average harvests." `https://documents.wfp.org/stellent/groups/internal/documents/projects/wfp285525.pdf?_ga=2.16811450.26079822.1526745463-1039467483.1526745463`

Figure 6: Impact of LWH on Harvest



The impact of LWH on total sales values is shown in Figure 7. **The results suggest that the treatment group has significantly greater sales than the comparison group across the project years and seasons.**

In line with positive results on the total sales values, we find an increase in the commercialization rate as a result of LWH (Figure 8). The rate of commercialization is the share of sales values per harvest values. **In Season A, the treatment group was able to sell roughly 7 percentage points to seventeen percentage points more than the comparison group, which has an average commercialization rate of approximately 20% across years.** Specifically in 2017A, the impact of the LWH on commercialization rate was 29 percentage points, relative to a comparison group mean of 22 %; and in Season B, an impact of 1 percentage point, relative to a comparison group mean of 26 %. Combined with the previous result on the total sales values, the data show LWH households were able to harvest more, and sell a greater proportion of their harvest. The results for Season B are more mixed. The difference between the treatment and comparison groups is only statistically significant in 2013 and 2014. The graphs indicate that while the treatment group did see higher sales value in 2017 Season B than the comparison group, the difference is negligible and not statistically significant.

Figure 7: Impact of LWH on Sales

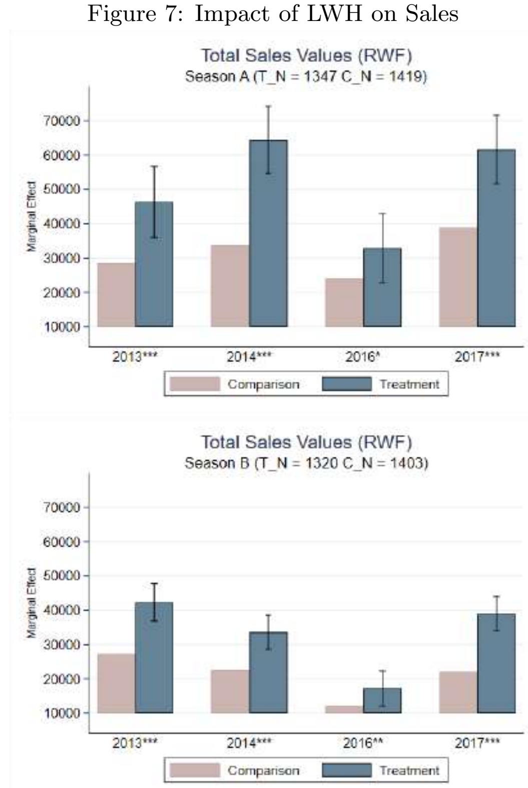


Figure 8: Impact of LWH on Commercialization Rate

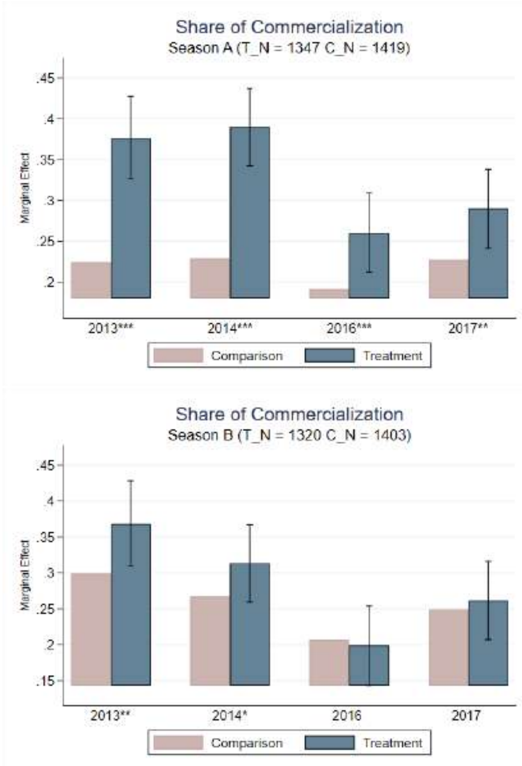
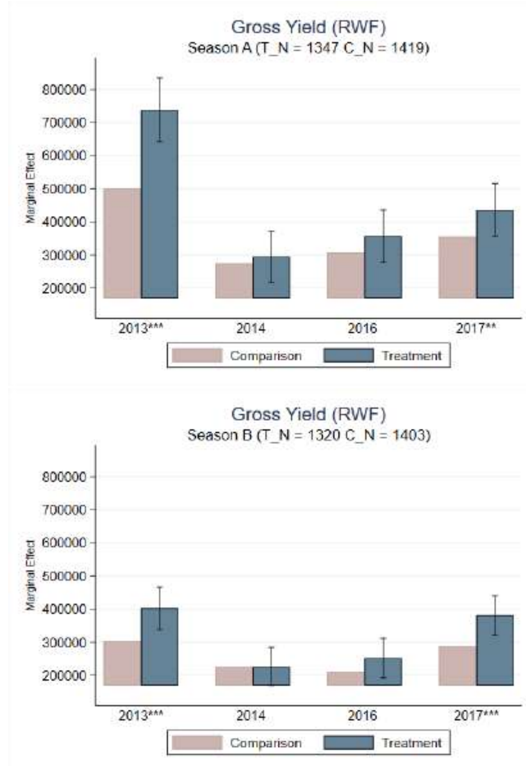


Figure 9: Impact of LWH on Gross Yield



The gross and net yields are measures of productivity. The gross yield is calculated by dividing the total harvest values by cultivated area, and the net yield by dividing the total harvest values minus the total input expenditures by cultivated area. Both indicators reflect the return per hectare of cultivated land, but the net yield also accounts for the cost of investment. Note that given that the regression analysis controls for total land area, these results can be thought of as the scale of production.

The project's impact on gross yield is shown in Figure 9. **The return per hectare is positively affected by the project, particularly in 2013 and 2017 in both Season A and B**. In 2017 Season A, the causal impact of LWH on gross yield is 26 %, relative to the control group's average yield of RWF 350,000. In 2017 Season B, the impact is 34 %, relative to the control group's average of RWF 290,000. The middle years show no statistical difference between the two groups.

Figure 10: Impact of LWH on Net Yield

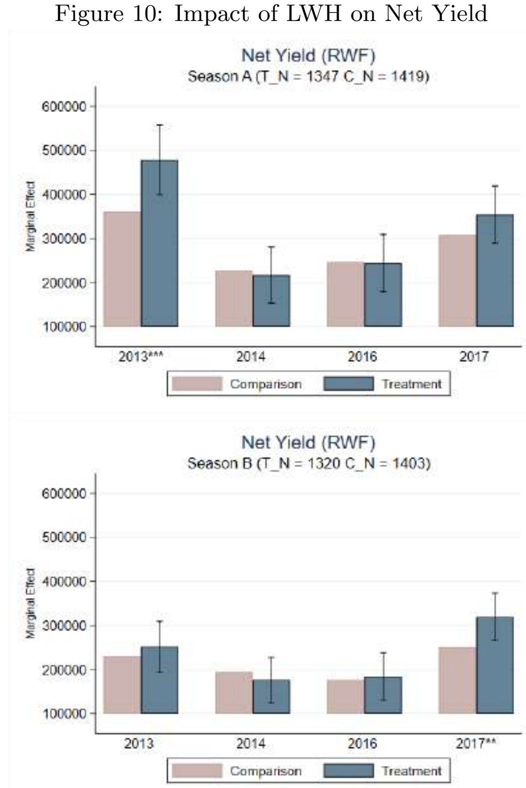


Figure 10 shows the impact of the project on net yield. Relative to gross yield return per hectare decreases once investment costs are considered, but the general trend across years does not change much from that of gross yield; the only statistically significant difference was in 2013 Season A (61% relative to a comparison group mean of RWF 370,000), and for 2017 Season B (28% relative to a comparison group mean of RWF 250,000).

This results present a puzzle and a direction for further investigation - is the household the appropriate unit of analysis for productivity? An alternate way to measure the impact of LWH on gross and net yield is to instead use plots as the unit of observation. Doing so might the efficacy of investment decisions more precisely, under the assumption that farmers make investment decisions at the plot level. The follow-up 4 and Endline surveys asked each respondent to match plots they reported in the current recall period to the last. This method enabled the research team to track each plot over the course of three project years, and to construct a longitudinal dataset with plots as the unit of observation. One disadvantage of this dataset is that the plots cannot be tracked back to the baseline. Hence, the regression results should be treated as simple comparisons between the treatment and comparison groups in each year. Figures 11 and 12 visualizes the regression results on gross and net yield with the plot-level longitudinal dataset.

Figure 11: Plot-level Impact of LWH on on Gross Yield

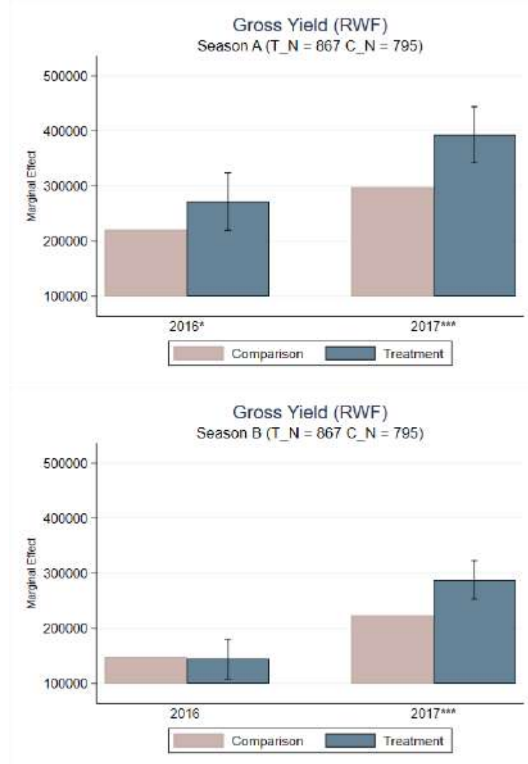
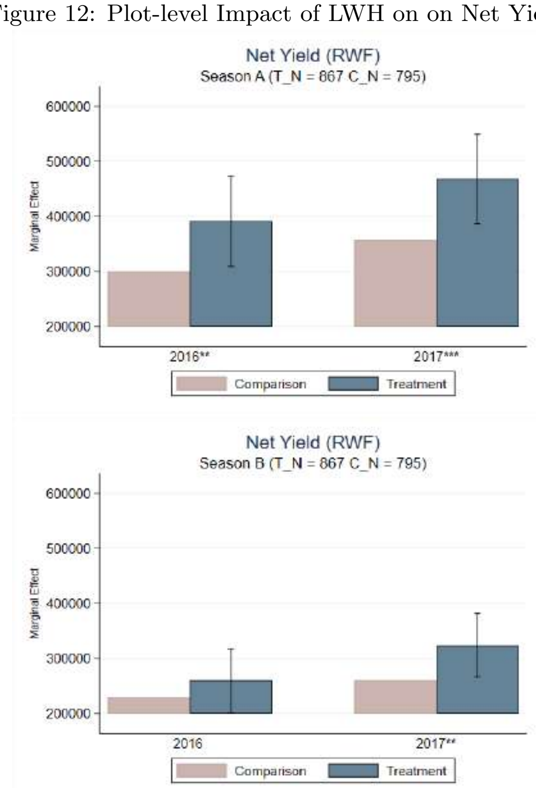


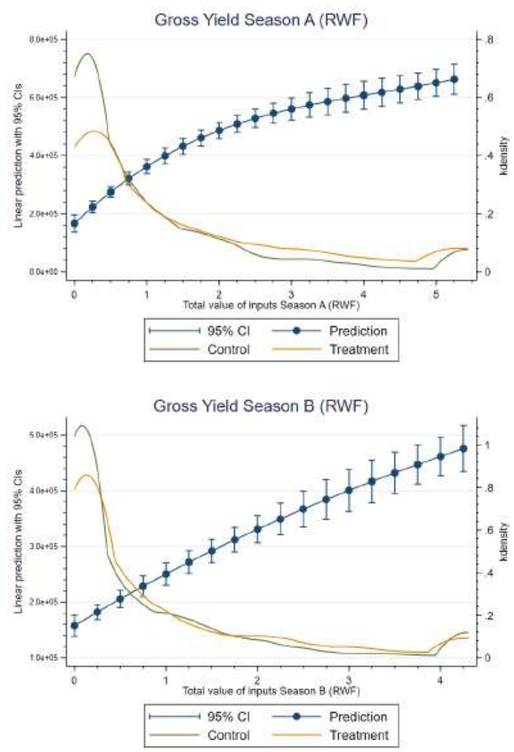
Figure 12: Plot-level Impact of LWH on on Net Yield



An initial reading of the evidence might suggest that the household and plot-level analyses are painting completely different pictures. However, there is another factor that may be driving the efficiency outcomes. The household level analysis on gross and net yield only captures the program effects on these indicators *on average*, and does not consider the distribution of this relationship. For instance, consider two farmers in the treatment group who share similar characteristics, except one of them spends a lot more on inputs. One may expect that a difference in the amount of positive effects that these farmers can gain from the project given the difference in input investment. In order to answer this question, the earlier specification explained in Section 4.2 is modified to include the squared and cubic terms of input spending. In order to answer this question, the earlier specification explained in Section 4.2 is modified to include the squared and cubic terms of input spending. The estimated results are then plotted over total input spending to visualize the return on input investment, with the sample distribution by treatment assignment over input spending. This allows us to understand whether or not the two farmers in the previous example have witnessed different outcomes.

Figure 13 shows the results on gross yield. The Season A graph depicts a non-linear relationship between the project effect on gross yield and input investment, while the Season B graph is much closer to a linear relation. This non-linearity in Season A hints that there is a variation in the return on input investments, and that the returns to scale are not constant. In other words, for individuals at the very bottom of the input-spending distribution, the return to additional input use can be quite different from those towards the top half of the distribution. The prediction line in blue is concave down, and its rate of change seems to slow down after around 20,000 RWF. However, the majority of the sample spends around 2,500 RWF in Season A, as shown in the kdensity lines in green and orange, where the rate of change on the prediction line is the most acute.

Figure 13: Return on Input - Gross Yield



The downward concavity observed in the Season A gross yield is more pronounced in the net yield results in both seasons (Figure 14). For Season A, the return on input investment starts to decrease after around 42,000 RWF of input spending. For Season B, the inflection point is around 40,000 RWF. This implies that a farmer who spends over 42,000 RWF benefits as much from the project as a farmer who 35,000 RFW in inputs. Given that the LWH project has also helped farmers gain access to inputs, and provided agricultural advice, targeting might be of high value in this suite of complimentary interventions. This will be further discussed in Section 6.

Figure 14: Return on Inputs - Net Yield

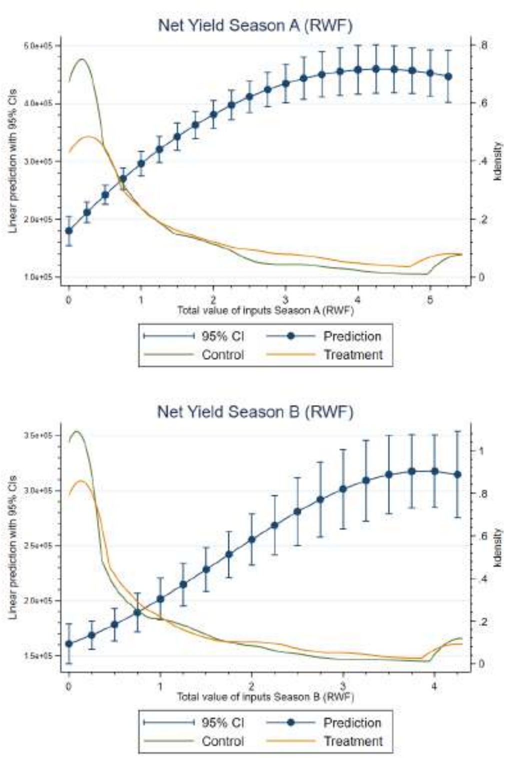
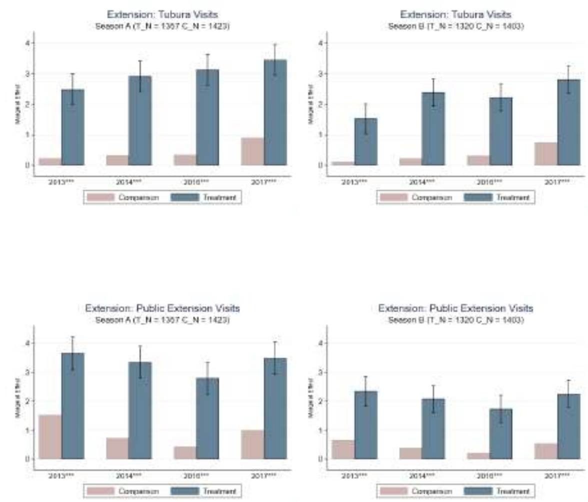


Figure 15: Impact of LWH on the Use of Agricultural Extension



5.2 Project Related Inputs

5.2.1 Extension

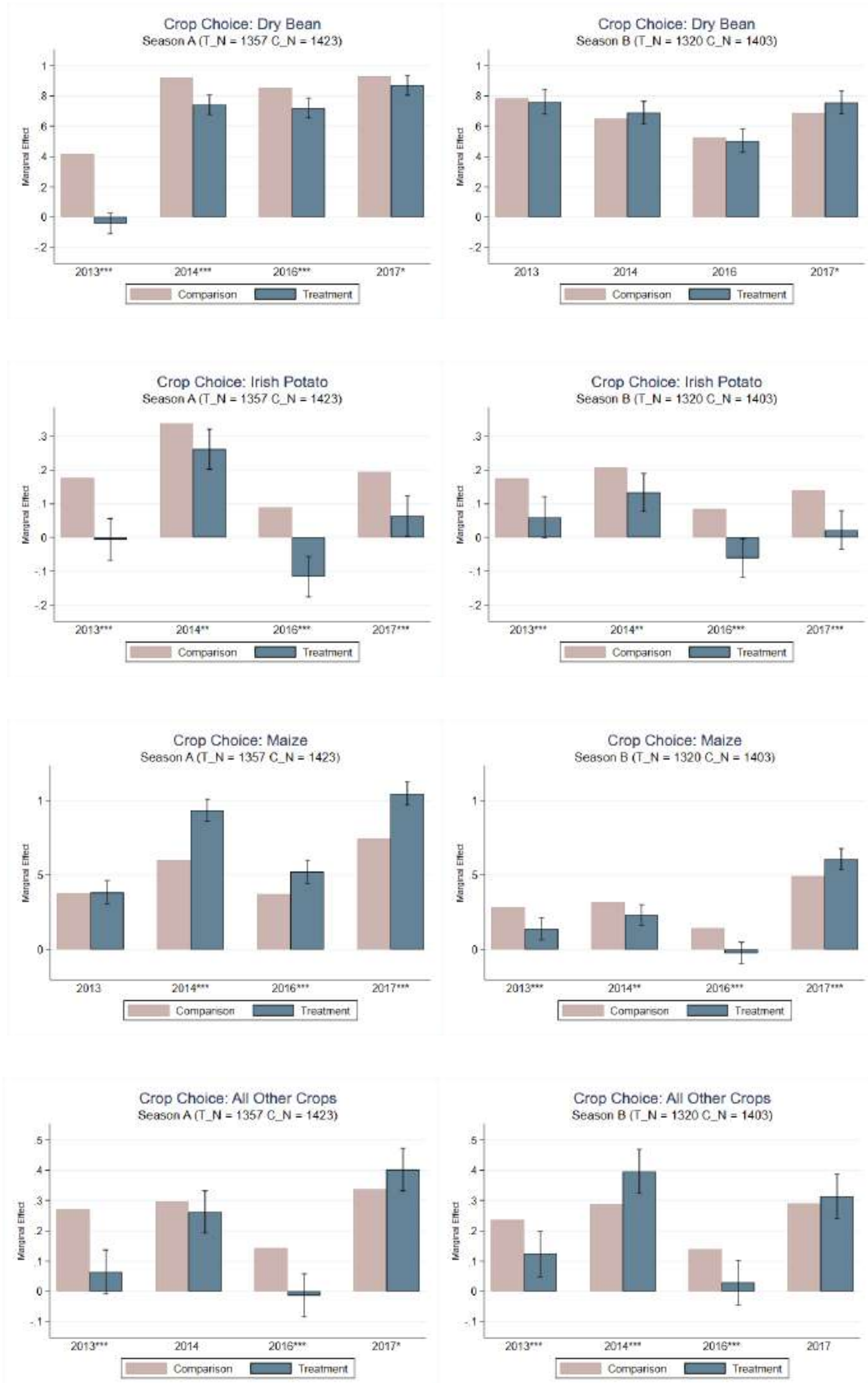
The provision of agricultural extension was an important component in the project. The project offered consulting services by Tubura officers, and public extension workers (LWH agronomists, sector agronomist, IDP officer and RAB officers). **Figure 15 shows the regression results. The treatment group were much more likely to be visited by Tubura and public extension officers compared to the comparison.**

5.2.2 Crop Choice

In this section, we examine the impact of LWH interventions on farmers' crop choices. The project aimed to promote the transition away from traditional inter-cropping to a system of cropping that relies on improved inputs and technology. Maize remained a key crop promoted by the project, and we also look into three other major crops in Rwanda: dry beans, Irish potatoes and sorghum. The choice to grow all other crops are listed for reference.

The impact of the project and choice on various crop types are shown in Figure 16. LWH households are statistically significantly less likely than comparison households to grow dry beans in Season A, while they are about as likely as comparison to grow dry beans in Season B. They are statistically significantly less likely to cultivate Irish potatoes across seasons and years. The result on maize reveals a different story. LWH households are statistically significantly more likely than comparison households to cultivate maize in Season A, while the story in Season B changes from year to year.

Figure 16: Impact of LWH on Crop Choice in Season A and B

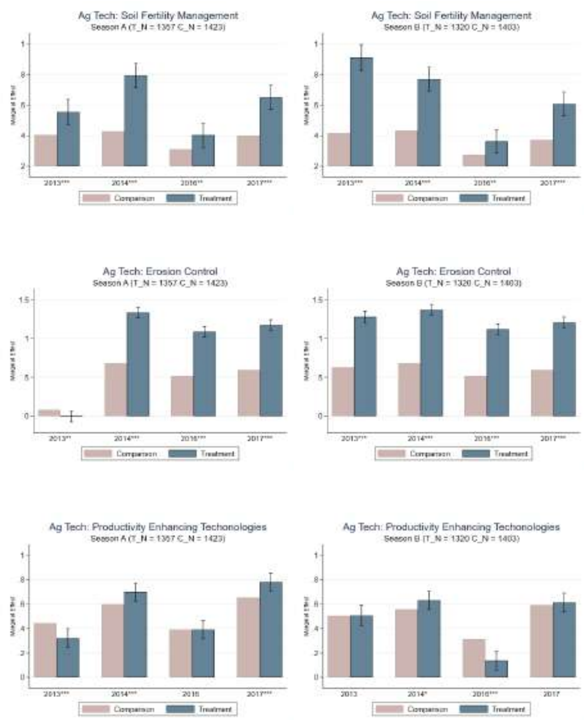


5.2.3 Agricultural Technologies

The project promoted the use of agricultural technologies in three areas: soil fertility management, erosion control and productivity enhancement. The project also provided radical terracing and hillside irrigation.

Figure 17 presents the regression results on all indicators. **In general, the LWH households are more likely to adopt various agricultural technologies throughout years and across seasons.** The results on erosion control and productivity enhancing technologies show that LWH households quickly surpass comparison households across these indicators. The positive outcomes seem to sustain over time. 2016 saw some reductions in adoption, but the 2017 numbers are closer to 2014 levels.

Figure 17: Impact of LWH on the Use of Agricultural Technologies

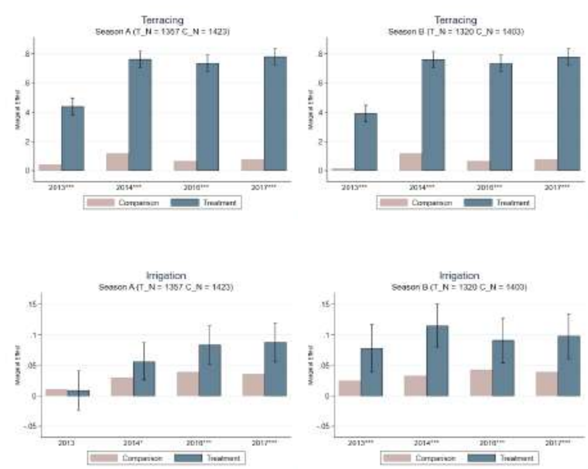


5.2.4 Terracing and Irrigation

One of the main aims of the project was to promote radical terracing and hillside irrigation to help increase agricultural productivity of rural farmers. Figure 18 shows the project's impact on terracing and irrigation. As the results make evident, the project has a strongly positive impact on the provision of these large and expensive services across years. The consistency in results on terracing are a result of this being a one-time investment at the plot level.

Compared to terracing, the use of irrigation in the sample is fairly low. There are two reasons for this. (1) In the sites under study, the irrigation systems had not turned on yet. (2) Irrigation is most useful in the dry season, that was not a core element of this study. DIME has been involved in a long-term study tracking dry-season cultivation in irrigation sites in a separate Impact Evaluation. Please refer to the *Irrigation Impact Evaluation Policy Brief* for more details on this.

Figure 18: Impact of LWH on Terracing and Irrigation

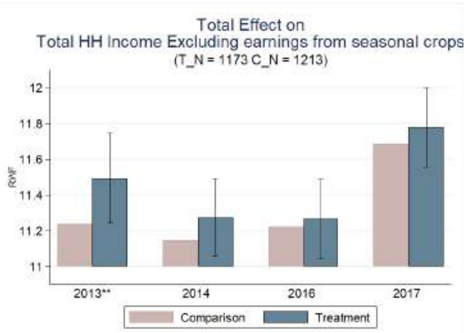


5.3 Non-agricultural outcomes (income, food security and banking behavior)

In this section, we investigate the project's potential influence on non-agricultural indicators including household income, food security and financial behavior. The underlying theory of change posits that non-agricultural outcomes at the household level improves as harvest and sales values increase. This might involve households having the financial capacity to invest in non-seasonal sources of income, including cattle and livestock products. The project has also incorporated a rural finance aspect to help rural farmers gain access to formal financial instruments and this outcome is also discussed here.

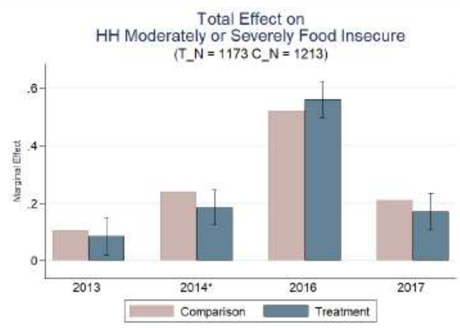
Figure 19 shows the project's impact on total household income excluding seasonal agricultural income. **While the result does not show strong statistical significance, it indicates that treatment households have consistently higher incomes than comparison households.** Additionally, incomes rose across the sample in 2017, after having been relatively stagnant for the first three years of our data.

Figure 19: Impact of LWH on Total Household Income



The result on food security is shown in Figure 20. Food security is calculated according to the composite food consumption score (FCS) methodology. **As Figure 20 shows, the treatment has generally had lower propensity of severe or moderate food insecurity without statistical significance, except in 2016.** In both LWH and comparison sites, the proportion of households reporting food insecurity grew substantially in 2016, but reduced dramatically in 2017. As of this most recent survey, the prevalence of food insecurity seems to have come down to the level comparable to 2014.

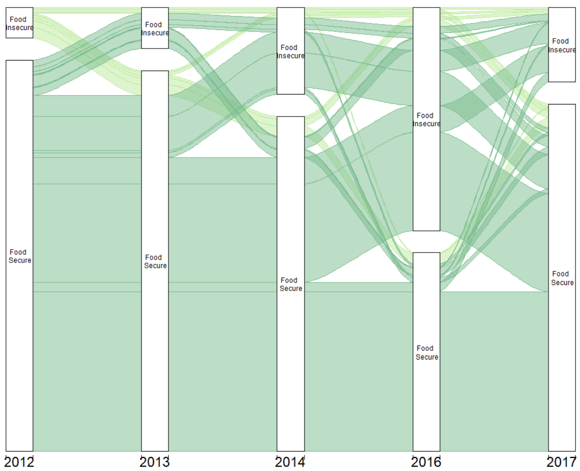
Figure 20: Impact of LWH on Food Insecurity Status



In order to further examine the household food security status, Figure 21 tracks the transition of all sample households' food security status across the project year. Each vertical bar represents a year in which data collection was collected. The vertical bar is divided into households that are food secure (in the bottom part of the bar) and those that are insecure (the top part). The key takeaway from this graph is the high variability in food security status over time. Only a small fraction of households remain food secure or food insecure throughout the life-cycle of data collection. This goes against conventional wisdom that households can stay food secure and that they remain food insecure over time. In this context, predicting food insecurity and targeting programs to tackle this issue is a major challenge.

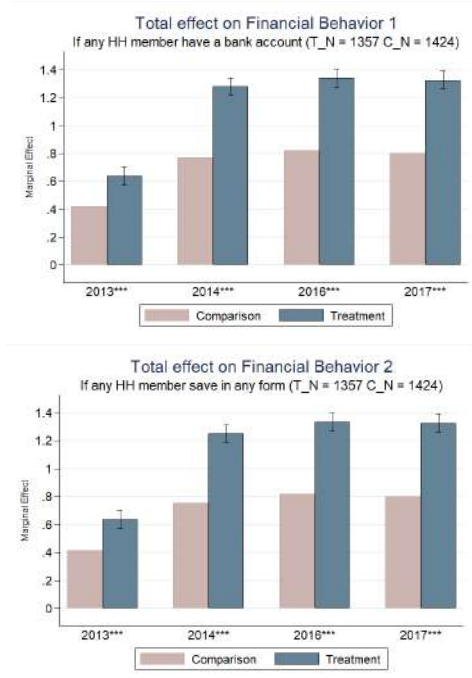
The relationship between the project and financial behavior is shown in Figure 22. We measure financial behavior through two indicators: whether any household member reports having a formal bank account, and whether any household member allocates some income towards savings. The relationship is significantly positive across the project years for both indicators. The result on saving is very encouraging as it shows that treatment households are much more likely to save.

Figure 21: Transition of Food Security Status 2012 to 2017



Note: This graph shows the distrbution of all households i.e. the pooled sample

Figure 22: Impact of LWH on Financial Behavior



6 Lessons Learned

The analysis in this report suggests that the LWH project has been a positive program for rural farmers, with strong results across a number of key agricultural indicators. Selected highlights of the program include: a positive impact on 2018 Season A harvests - 36 % relative to a comparison group mean of RWF 110,000; a positive impact on 2018 Season B sales - 60 % relative to a comparison mean of RWF 75,000; and a positive impact on 2018 Season A commercialization rate of 7 percentage points relative to a comparison mean of 22 %. The project was also able to promote cash cropping of maize and the use of agricultural technologies and access to extension services for beneficiary households. In 2018, households in LWH sites were 26 percentage points more likely to be visited by a public extension officers, relative to the comparison group where 9 % of households reported the same. The project also resulted in positive effects on having a bank account - with 50 % more likelihood for account holding for households in LWH sites. **In addition, the positive results in 2018 represent an acceleration over previous years, and the pattern of incrementally higher impacts year-on-year continues to hold true.**

The results from this report propose three key areas for understanding the impact of LWH and its relationship to future program. First, the wide geographical coverage of LWH ensured that the program reached farmers from a wide distribution. This presents both opportunities and challenges. On the one hand, wide geographic coverage is necessary to allow for large infrastructure development. These investments are key in shifting the production possibility frontier(PPF) and enabling a rural transformation. On the other hand, this implies a large amount of heterogeneity across targeted farming households facing a wide variety of constraints to increase their on-farm productivity and get closer to the PPF. Hence, program impact could be maximized by combining wide geographic coverage with targeted complementary interventions. These interventions could cover a range of constraints on the input market and information failures, as well as constraints on the output market, and could target different types of farmers.

Second, the data points to the positive impacts of LWH on cultivation in the rainy seasons, especially during the long rains in Season A. Impact pathways for improved production include a variety of technology and input-related interventions. However, variations in outcomes across seasons remain apparent and are likely driven by limited access to water in the dry seasons. While nearly eighty percent of the households in LWH sites reported having at least one irrigated plot, less than 10 percent reported to have at least one irrigated plot in both seasons. Further work is being done to capture the impacts and sustainability of irrigation access through LWH (Jones, Kondylis, Loeser, Magruder 2018), and will shed light on this subject.

Lastly, the investigation of the transitions of household food security status reveals how fluid these classifications are, and the high unpredictability of this indicator from one year to the next. Only a small minority of households are always food secure or always food insecure. This points to the challenge in designing programs that target food insecure households, driven by the variation in this outcome within and across years. Investments that seek to affect this outcome are often thought of as gaining efficiency from intensive (and often costly) targeting, but data from this study indicates the intricacy of targeting such programs.

A Balance Test on the Remaining Variables

Figure 23: Balance Table on the Remaining Variables (1B)

	(1) Treatment		(2) Control		T-test Difference
Variable	N	Mean/SE	N	Mean/SE	(1)-(2)
If a Tubura field officer visited in Season A	289	0.014 (0.007)	300	0.000 (0.000)	0.014**
If a public extension worker visited in Season A	289	0.052 (0.013)	300	0.017 (0.007)	0.035**
If any plot was radical-terraced in Season A	289	0.003 (0.003)	302	0.000 (0.000)	0.003
If adopted soil fertility technologies in Season A	289	0.578 (0.029)	300	0.367 (0.028)	0.211***
If adopted erosion control techonologies in Season A	289	0.284 (0.027)	300	0.247 (0.025)	0.037
If adopted productivity enhancing techonologies in Season A	289	0.792 (0.024)	300	0.697 (0.027)	0.096***
If any plot was irrigated in Season A	289	0.045 (0.012)	300	0.020 (0.008)	0.025*
If sorghum was planted in Season A	289	0.035 (0.011)	300	0.033 (0.010)	0.001
If Irish potato was planted in Season A	289	0.176 (0.022)	300	0.247 (0.025)	-0.070**
If dry bean was planted in Season A	289	0.799 (0.024)	300	0.850 (0.021)	-0.051
If maize was planted in Season A	289	0.502 (0.029)	300	0.467 (0.029)	0.035
If a Tubura field officer visited in Season B	289	0.014 (0.007)	300	0.000 (0.000)	0.014**
If a public extension worker visited in Season B	289	0.052 (0.013)	300	0.017 (0.007)	0.035**
If any plot was radical-terraced in Season B	289	0.000 (0.000)	302	0.000 (0.000)	N/A
If adopted soil fertility technologies in Season B	289	0.450 (0.029)	300	0.293 (0.026)	0.156***
If adopted erosion control techonologies in Season B	289	0.246 (0.025)	300	0.217 (0.024)	0.029
If adopted productivity enhancing techonologies in Season B	289	0.817 (0.023)	300	0.680 (0.027)	0.137***
If any plot was irrigated in Season B	289	0.066 (0.015)	300	0.017 (0.007)	0.049***
If sorghum was planted in Season B	289	0.529 (0.029)	300	0.513 (0.029)	0.016
If Irish potato was planted in Season B	289	0.190 (0.023)	300	0.210 (0.024)	-0.020
If dry bean was planted in Season B	289	0.661 (0.028)	300	0.677 (0.027)	-0.016
If maize was planted in Season B	289	0.315 (0.027)	300	0.273 (0.026)	0.042

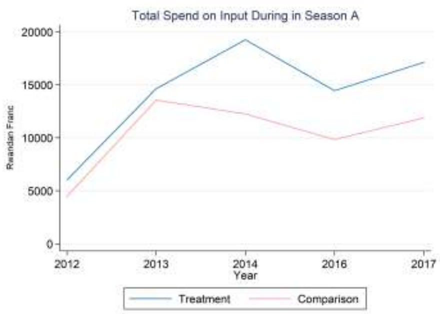
Notes: The value displayed for t-tests are the differences in the means across the groups. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

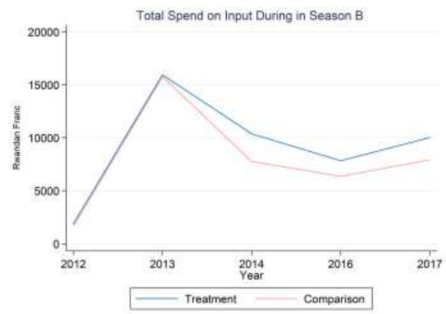
B Trends on Key Indicators (1B)

B.1 Agricultural Production

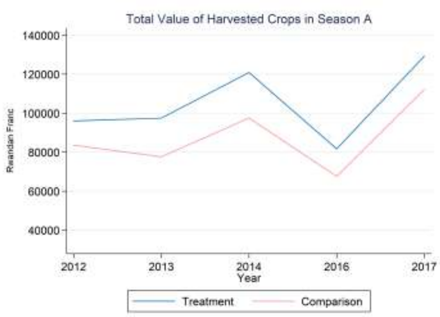
Figure 24: Trends on Agricultural Indicators 1

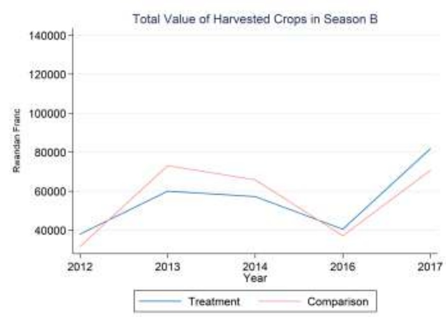
(a) Input Values



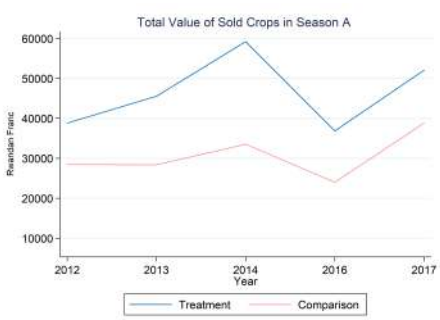


(b) Harvest Values





(c) Sales Values



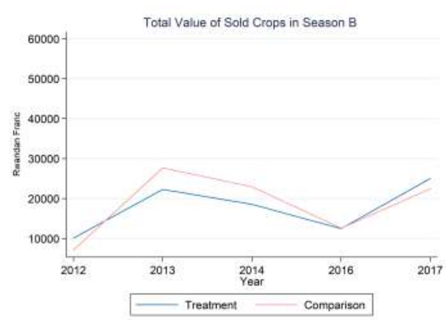
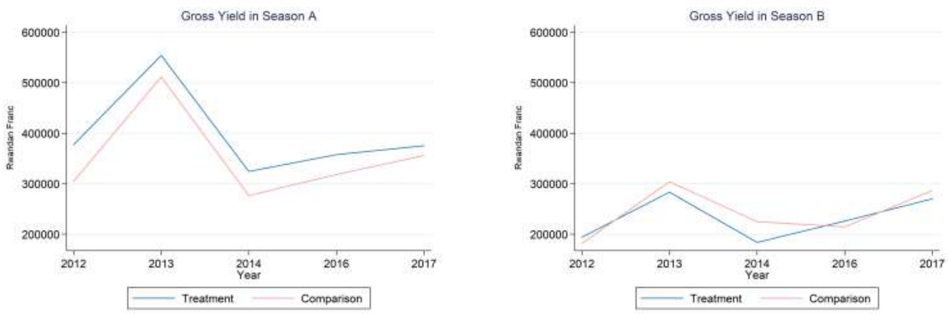
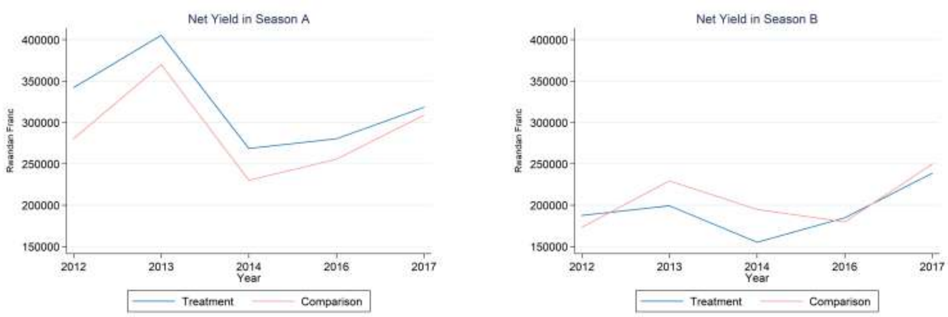


Figure 25: Trends on Agricultural Indicators 2

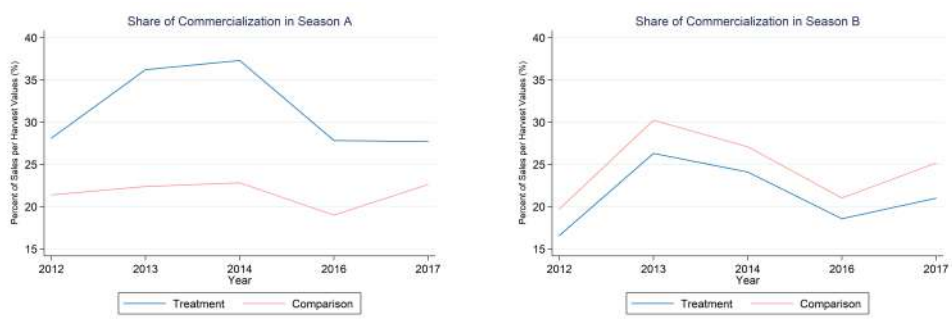
(a) Gross Yield



(b) Net Yield



(c) Share of Commercialization

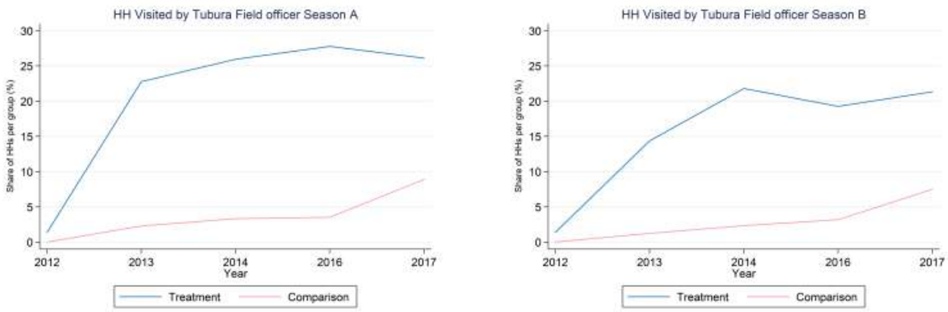


B.2 Project Related Inputs

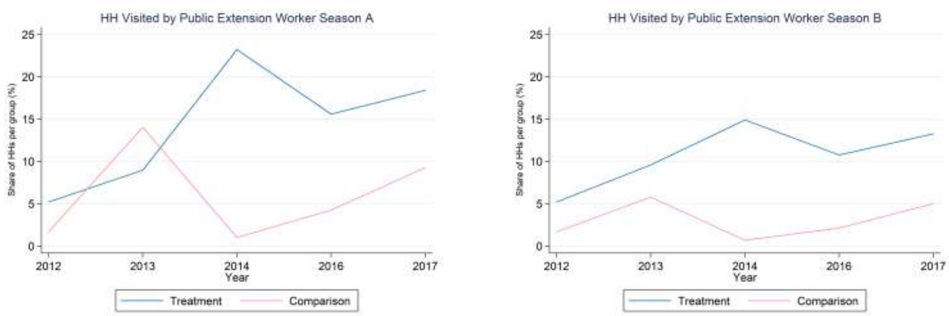
B.2.1 Extensions

Figure 26: Trends on Extension

(a) Tubura Visits



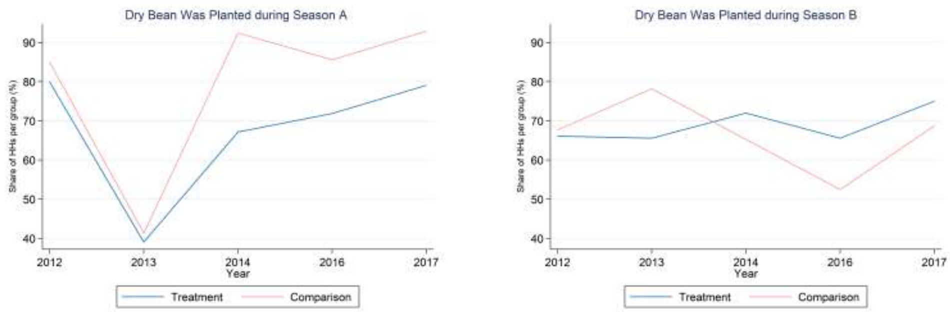
(b) Public Extention Officer



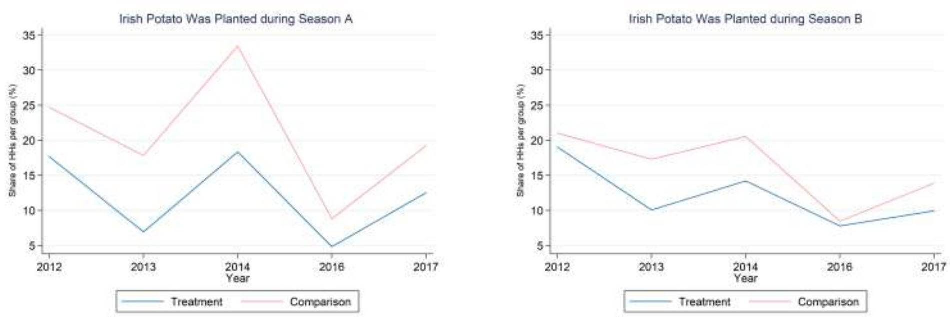
B.2.2 Crop Choices

Figure 27: Trends on Crop Choice

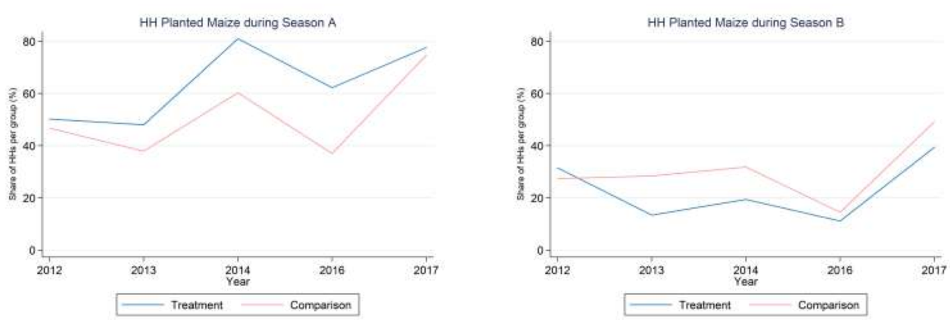
(a) Dry Bean



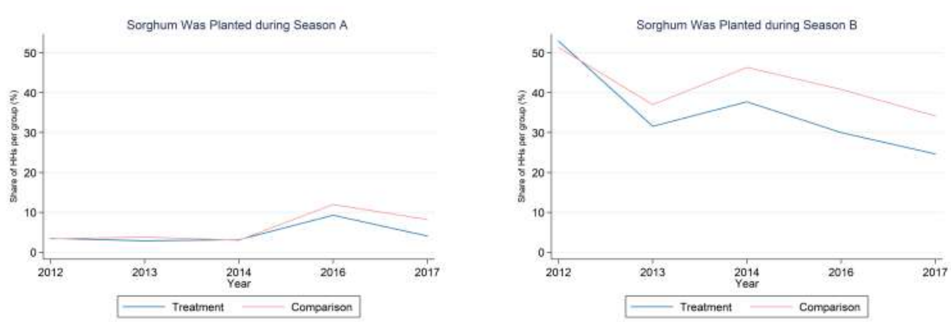
(b) Irish Potato



(c) Maize



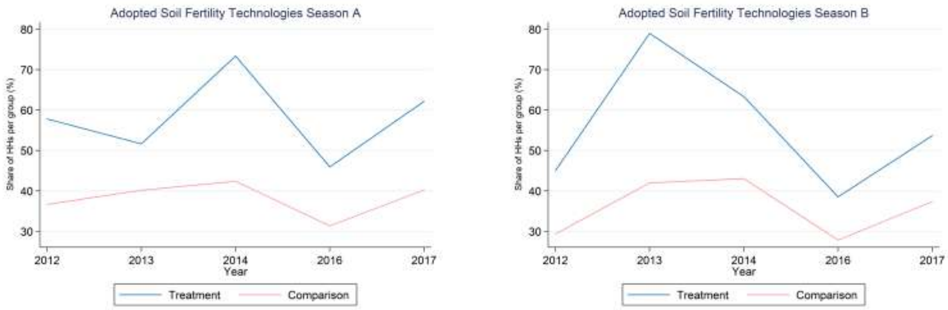
(d) Sorghum



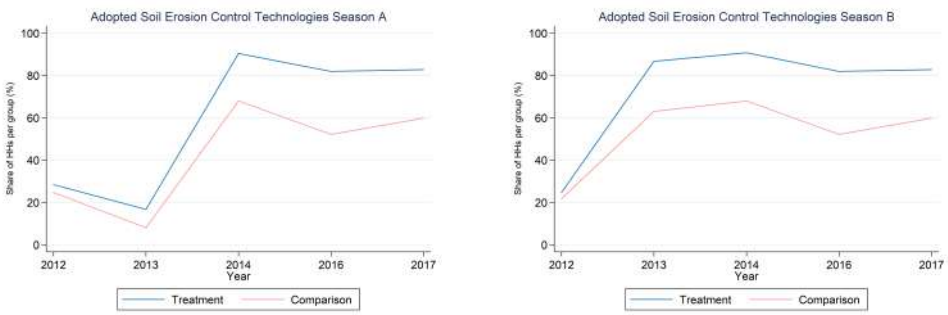
B.2.3 Agricultural Technologies

Figure 28: Trends on Adoption of Ag-Technologies

(a) For Soil Fertility



(b) For Erosion Control



(c) For enhancing productivity

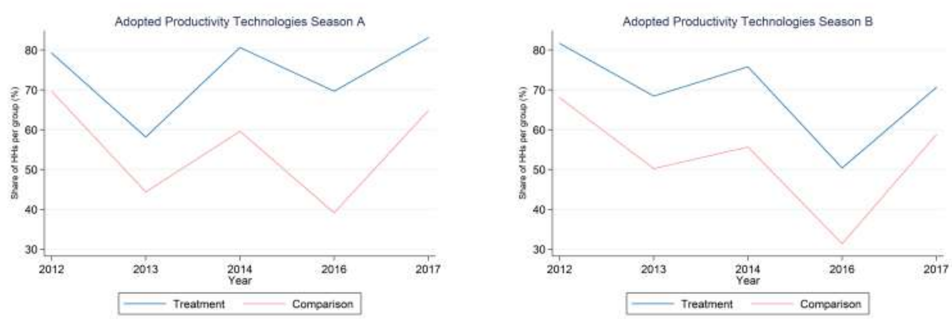
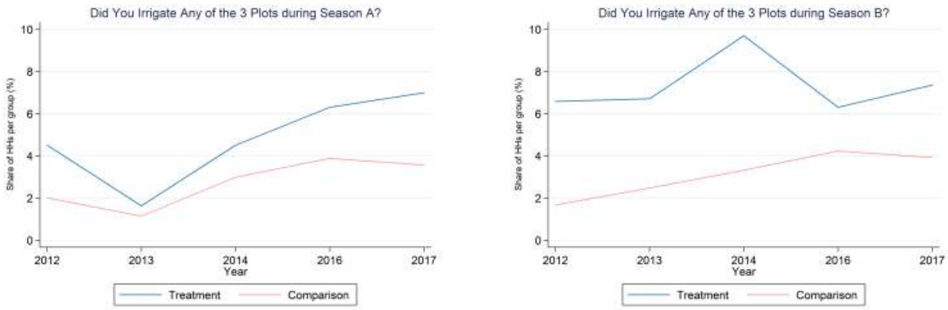
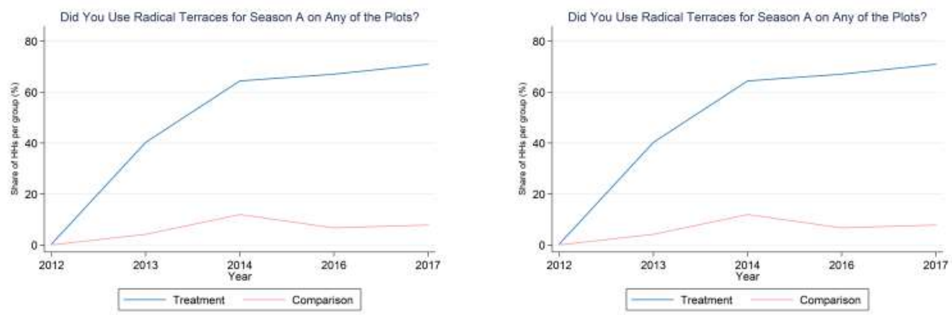


Figure 29: Trends on Adoption of Irrigation and Terracing

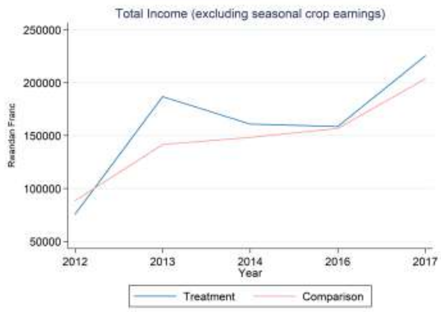
(a) Irrigation

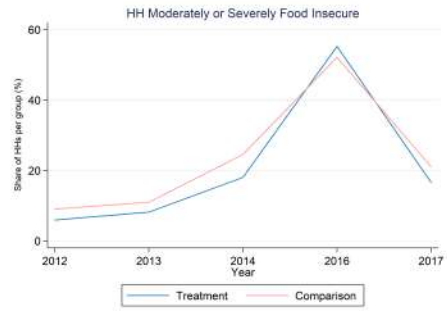


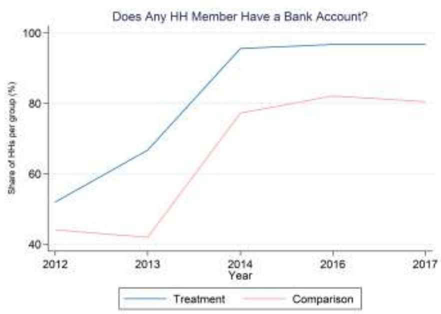
(b) Terracing

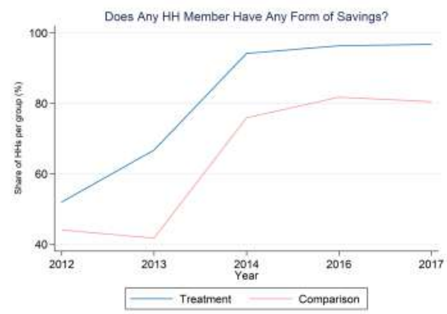


B.3 Non-agricultural Outcomes









C Results - 1C Households

C.1 Brief on the 1C results

As mentioned in Section 4.1, the main analytical section of the report focused on the 1B sample, due to baseline imbalance across a number of key variables for the 1C sample - presented in Table C.2. It is notable that there are statistically significant differences on input spending in Season A and B, total harvest and sales values, and gross and net yield in Season B. In each case, outcomes for the comparison groups are better than the treatment group. Nonetheless, with the statistical strategy described in Section 4.2, it is still possible to show understand correlations between the LWH project and outcome for this sample.

The trend graphs (Figures 33c and 34c) reflect the results shown in Table C.2, and reveals baseline imbalance, where the average levels of indicators are higher for comparison group for the treatment. This difference persists across years, particularly for input spending and gross yield (both seasons), harvest and sales values, net yield, and share of commercialization (Season B).

The project's correlation with agricultural production is shown in C.3. The project is generally correlated positively with all outcomes except the share of commercialization in Season A. Harvest, sales and yields are positively correlated with the project in 2017, while there is no statistical difference between the treatment and comparison groups for the share of commercialization. The Season B results are much more mixed. Harvest, sales and commercialization show significant negative correlation in 2016, although they turn around in 2018.

Section C.4.1 presents the results on crop choice. The regression results (Figure 37) does present a clear picture of the effect of the project on maize cultivation. The trend on maize cultivation (Figure 36d), shows that the treatment group surpassed the comparison group in planting maize only after 2016.

The correlation between the project and agricultural extensions is shown in Section C.4.2. The treatment group is more likely to be visited by Tubura officers and public extension officers, although the result is only statistically significant in 2018. The use of agricultural technologies are, for the most part, positively correlated with the project.

Lastly, the results on the non-agricultural indicators are presented in Section C.5. The regression analysis shows that this outcome is not correlated to the project. The graph on the change in household food security status shows the high degree of variation and transition across food security status over project years.

The correlation between the project and financial behavior is positive. The regression analysis shows that the treatment group has more likely to hold a bank account and save. This makes an intuitive sense given that the LWH project incorporated a rural finance component which promoted the access to formal banking among rural farmers.

C.2 Balance Table on 1C Households

Figure 31: Balance Table 1

	(1)		(2)		T-test
	Treatment		Control		Difference
Variable	N	Mean/SE	N	Mean/SE	(1)-(2)
Age of the head of the household at the baseline	177	48.554 (1.179)	272	46.570 (0.859)	1.984
Gender of the head of the household at the baseline	177	0.684 (0.035)	272	0.643 (0.029)	0.040
If the household head completed the primary education	177	0.260 (0.033)	272	0.239 (0.026)	0.021
Area of the plots the household owned at the baseline	177	1.369 (0.580)	272	0.821 (0.058)	0.549
If public tap is the primary source of water at the baseline	177	0.316 (0.035)	272	0.243 (0.026)	0.074*
If paraffin is the main source of light at the baseline	177	0.079 (0.020)	272	0.026 (0.010)	0.053***
HH moderately or severely food insecure	177	0.209 (0.031)	272	0.169 (0.023)	0.040
Total value of harvests in Season A	177	59476.452 (4407.581)	272	64278.739 (3934.191)	-4802.287
Total value of sales in Season A	177	20326.540 (2690.154)	272	20150.414 (2108.480)	176.126
Total spending on inputs in Season A	177	6783.119 (675.186)	272	9153.743 (690.782)	-2370.624**
Total area cultivated (ha) in Season A	177	0.344 (0.028)	272	0.382 (0.023)	-0.039
Gross yield in Season A	160	2.86e+05 (26774.429)	253	2.88e+05 (21525.719)	-1645.096
Net yield in Season A	160	2.49e+05 (23959.263)	253	2.36e+05 (19070.600)	12820.433
Total value of harvests in Season B	177	41947.037 (3267.127)	272	54296.958 (3063.503)	-1.23e+04***
Total value of sales in Season B	177	11932.299 (1648.142)	272	18031.739 (1647.835)	-6099.440**
Total spending on inputs in Season B	177	4657.797 (542.782)	272	6968.199 (580.522)	-2310.402***
Total area cultivated (ha) in Season B	177	0.341 (0.027)	272	0.375 (0.021)	-0.035
Gross yield in Season B	159	1.81e+05 (16380.474)	251	2.26e+05 (15612.517)	-4.55e+04*
Net yield in Season B	159	1.53e+05 (14988.816)	251	1.90e+05 (13894.422)	-3.73e+04*

Notes: The value displayed for t-tests are the differences in the means across the groups. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

Figure 32: Balance Table 2

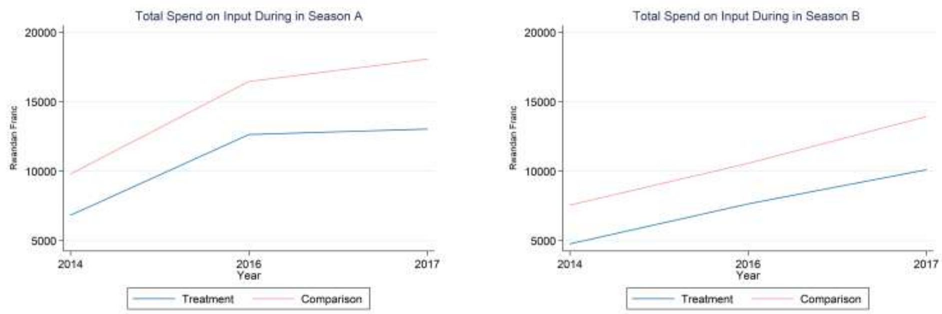
Variable	(1) Treatment N	(1) Treatment Mean/SE	(2) Control N	(2) Control Mean/SE	T-test Difference (1)-(2)
If a Tubura field officer visited in Season A	177	0.000	272	0.000	N/A
		(0.000)		(0.000)	
If a public extension worker visited in Season A	177	0.090	272	0.088	0.002
		(0.022)		(0.017)	
If any plot was radical-terraced in Season A	177	0.678	272	0.640	0.038
		(0.035)		(0.029)	
If adopted soil fertility technologies in Season A	177	0.339	272	0.335	0.004
		(0.036)		(0.029)	
If adopted erosion control techonologies in Season A	177	0.836	272	0.813	0.024
		(0.028)		(0.024)	
If adopted productivity enhancing techonologies in Season A	177	0.492	272	0.544	-0.053
		(0.038)		(0.030)	
If any plot was irrigated in Season A	177	0.062	272	0.059	0.003
		(0.018)		(0.014)	
If sorghum was planted in Season A	177	0.017	272	0.011	0.006
		(0.010)		(0.006)	
If Irish potato was planted in Season A	177	0.203	272	0.243	-0.039
		(0.030)		(0.026)	
If dry bean was planted in Season A	177	0.881	272	0.864	0.017
		(0.024)		(0.021)	
If maize was planted in Season A	177	0.260	272	0.261	-0.001
		(0.033)		(0.027)	
If a Tubura field officer visited in Season B	177	0.000	272	0.000	N/A
		(0.000)		(0.000)	
If a public extension worker visited in Season B	177	0.062	272	0.074	-0.011
		(0.018)		(0.016)	
If any plot was radical-terraced in Season B	177	0.678	272	0.640	0.038
		(0.035)		(0.029)	
If adopted soil fertility technologies in Season B	177	0.350	272	0.338	0.012
		(0.036)		(0.029)	
If adopted erosion control techonologies in Season B	177	0.847	272	0.813	0.035
		(0.027)		(0.024)	
If adopted productivity enhancing techonologies in Season B	177	0.458	272	0.529	-0.072
		(0.038)		(0.030)	
If any plot was irrigated in Season B	177	0.056	272	0.066	-0.010
		(0.017)		(0.015)	
If sorghum was planted in Season B	177	0.605	272	0.485	0.119**
		(0.037)		(0.030)	
If Irish potato was planted in Season B	177	0.136	272	0.206	-0.070*
		(0.026)		(0.025)	
If dry bean was planted in Season B	177	0.559	272	0.618	-0.058
		(0.037)		(0.030)	
If maize was planted in Season B	177	0.198	272	0.162	0.036
		(0.030)		(0.022)	

Notes: The value displayed for t-tests are the differences in the means across the groups. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level.

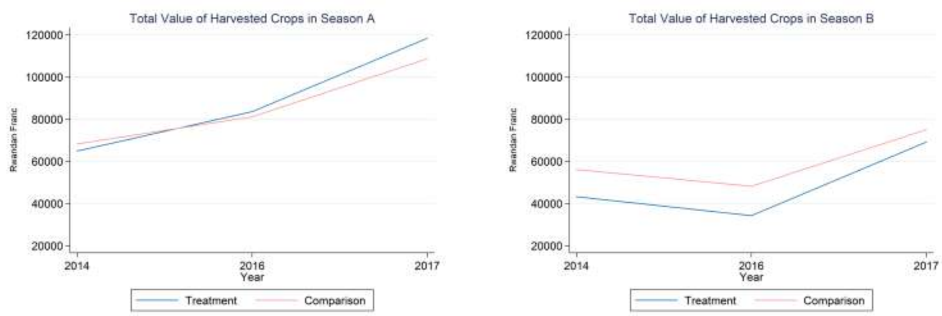
C.3 Agricultural Production

Figure 33: Trends on Agricultural Indicators 1

(a) Input Values



(b) Harvest Values



(c) Sales Values

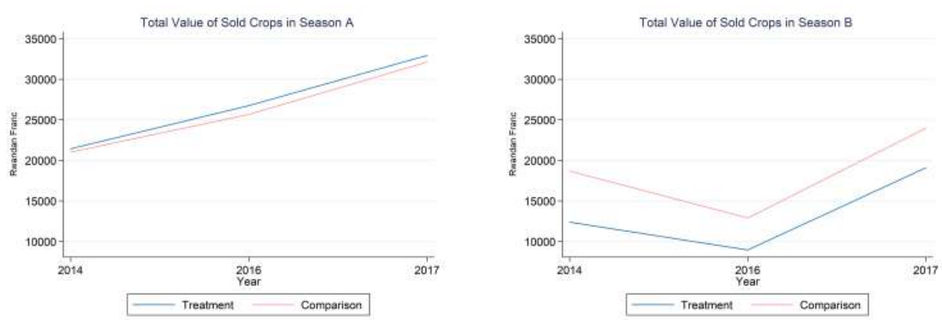
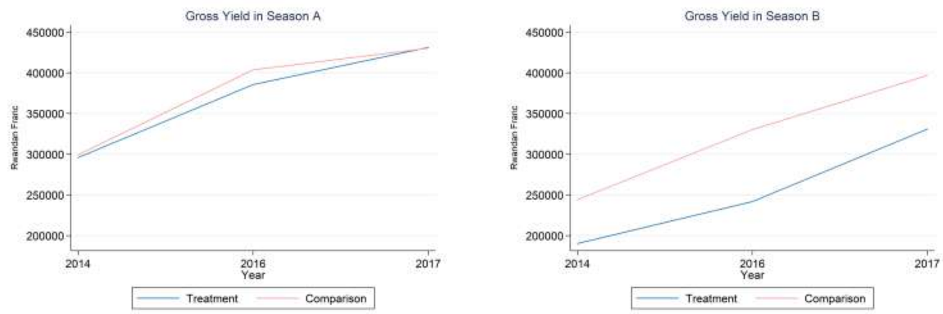
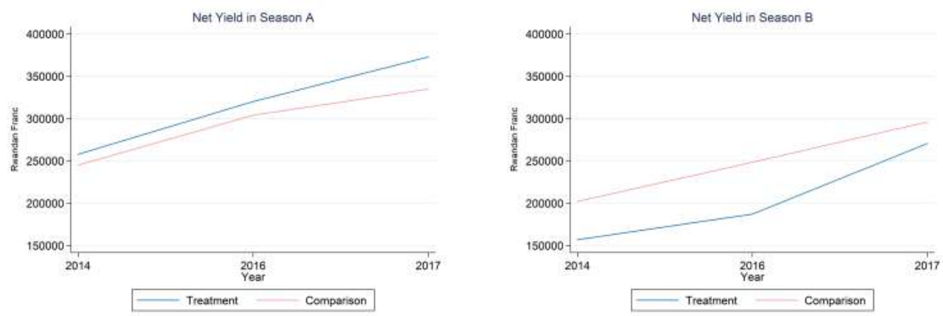


Figure 34: Trends on Agricultural Indicators 2

(a) Gross Yield



(b) Net Yield



(c) Share of Commercialization

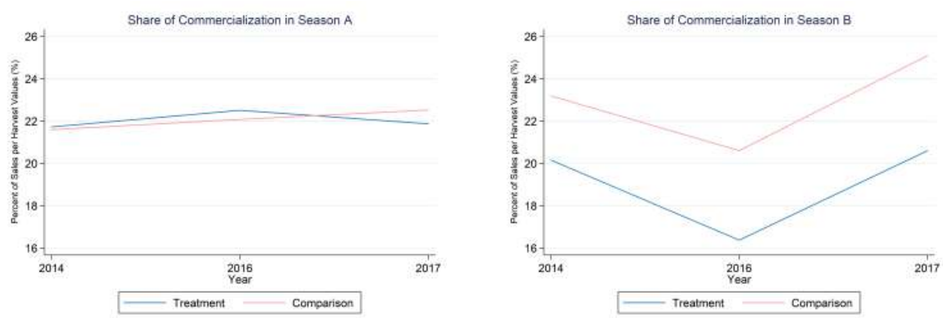
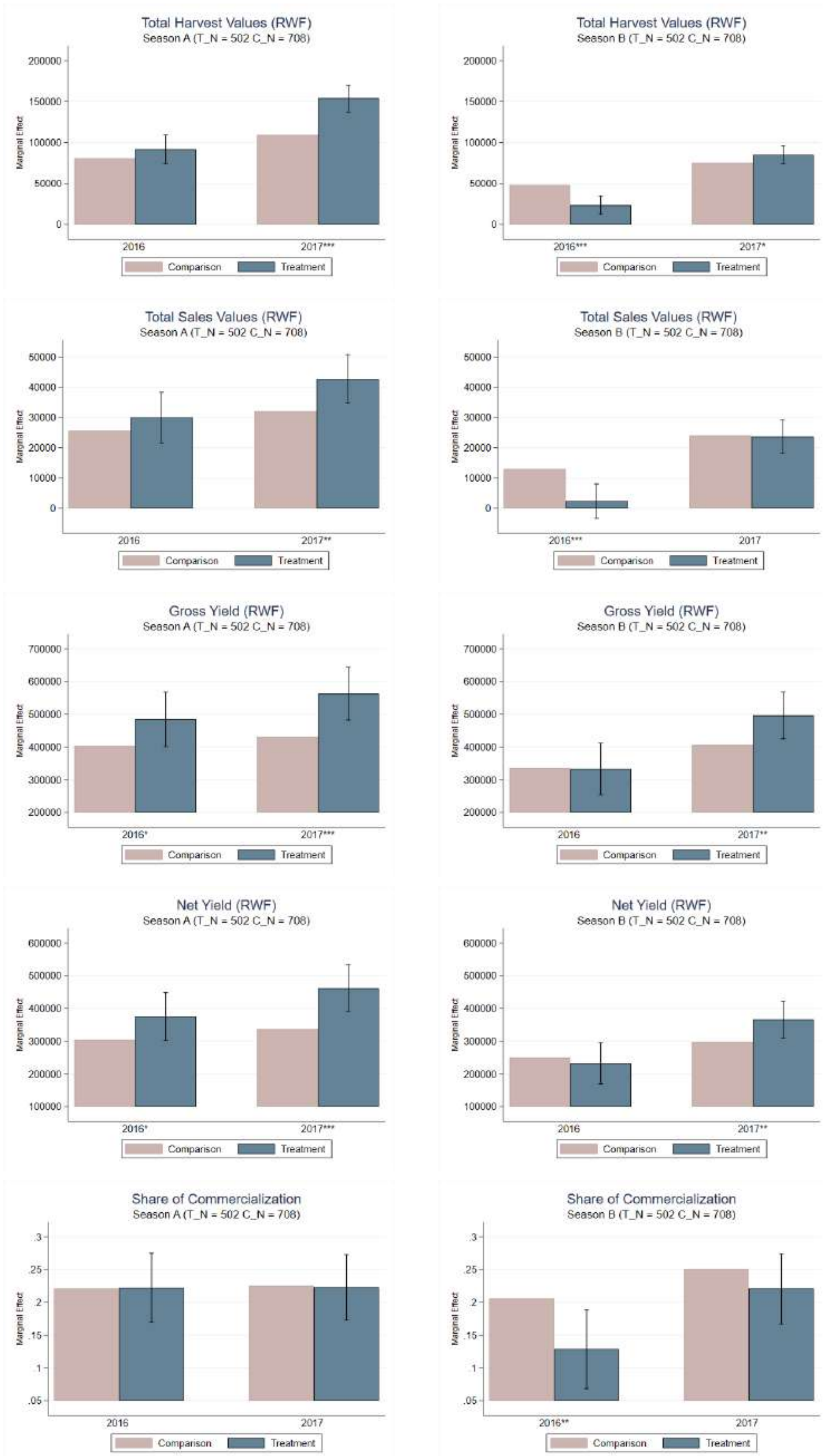


Figure 35: Correlation with Agricultural Production

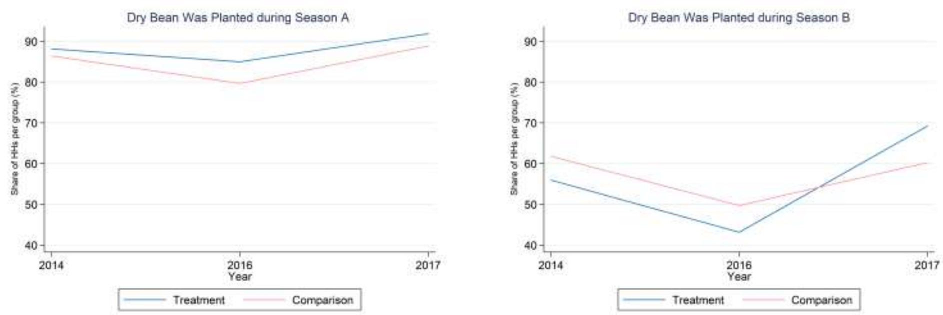


C.4 Project-related Inputs

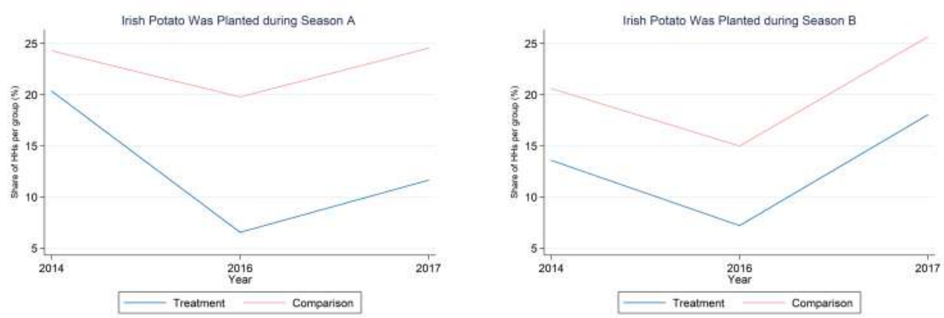
C.4.1 Crop Choice

Figure 36: Trends on Crop Choices

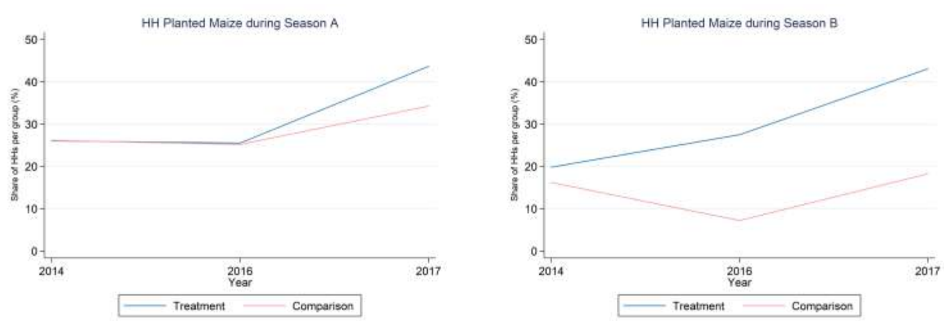
(a) Dry Bean



(b) Irish Potato



(c) Maize



(d) Sorghum

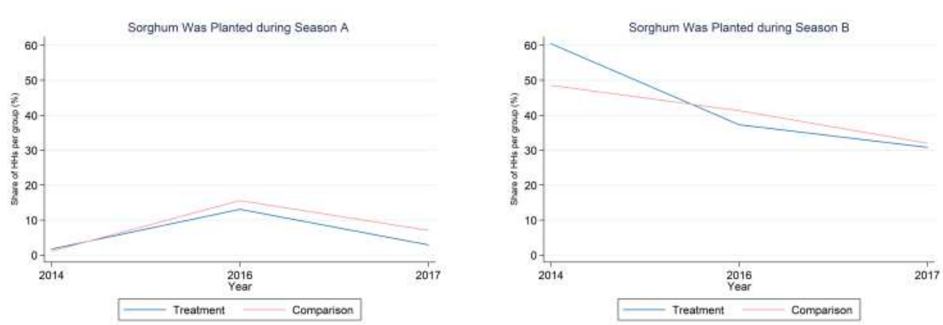
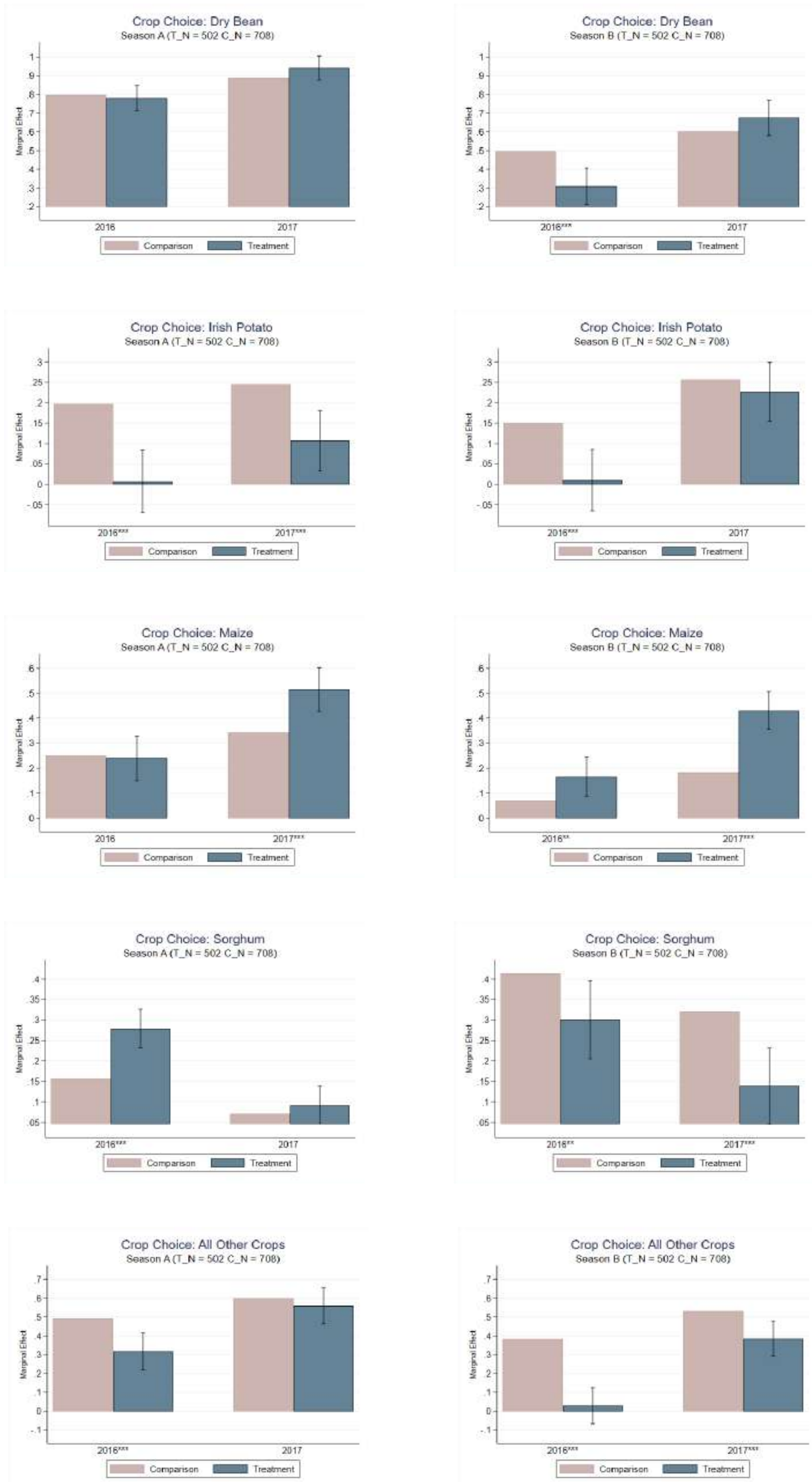


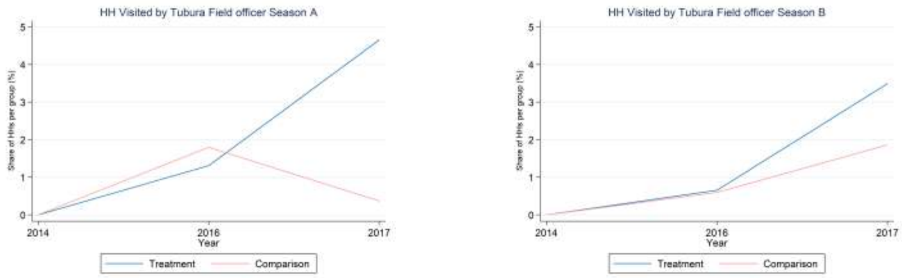
Figure 37: Correlation with Crop Choice in Season A and B



C.4.2 Extension

Figure 38: Trends on the Use of Extensions

(a) Tubura Visits



(b) Public Extention Officer

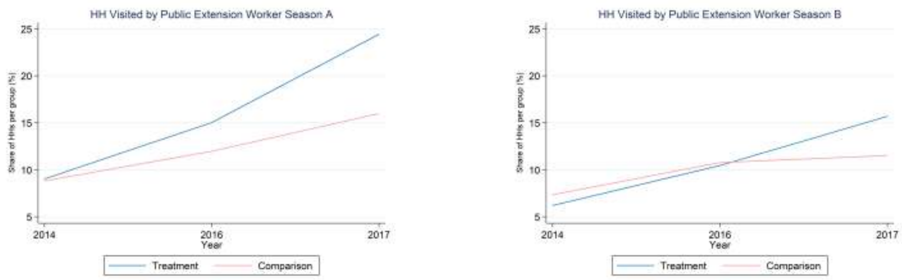
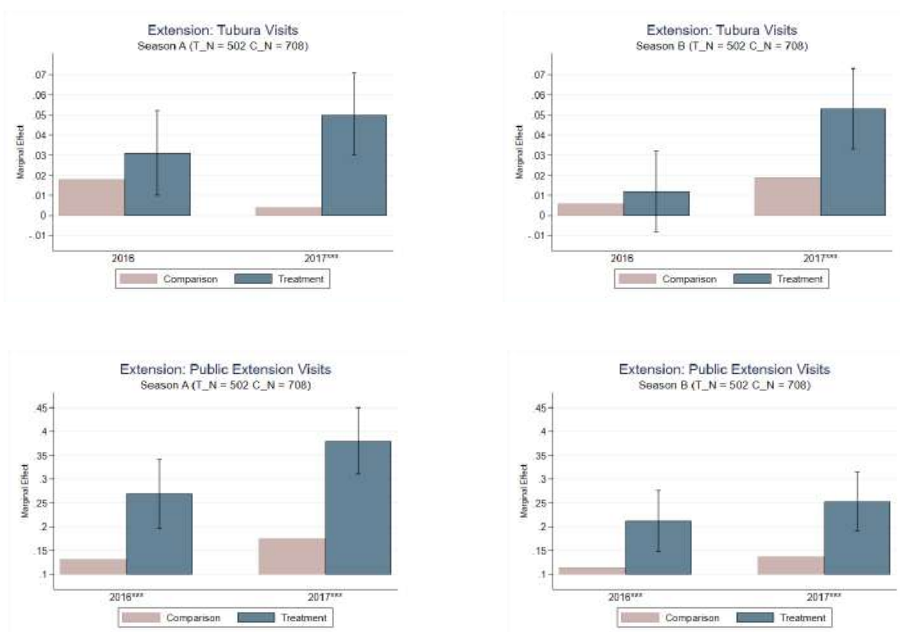


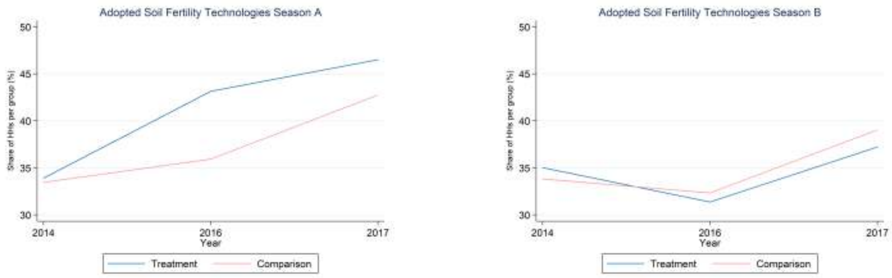
Figure 39: Correlation with the Use of Agricultural Extension



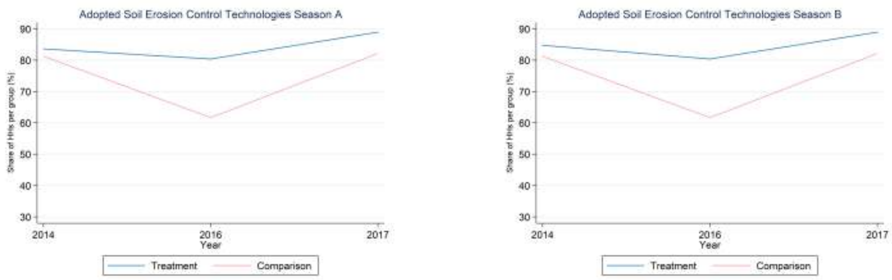
C.4.3 Agricultural Technologies

Figure 40: Trends on the Use of Agricultural Technologies

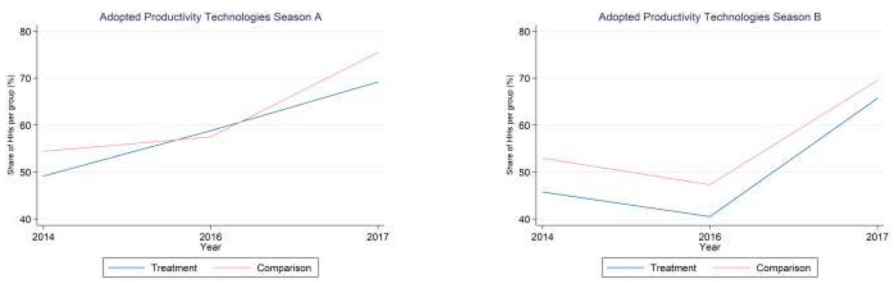
(a) For Soil Fertility



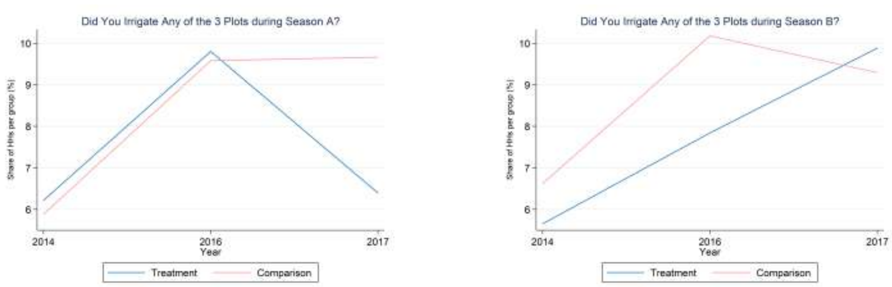
(b) For Erosion Control



(c) For enhancing productivity



(d) For Irrigation



(e) For Terracing

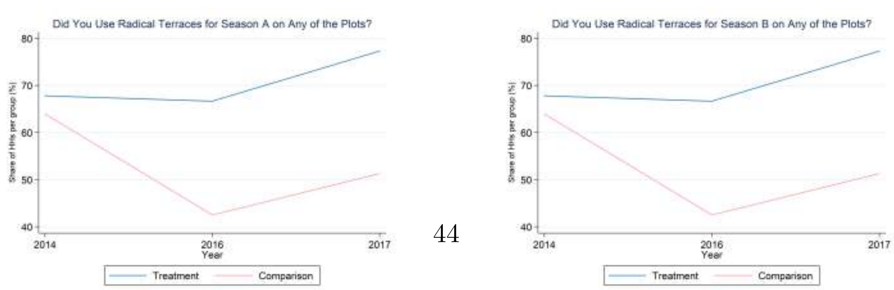
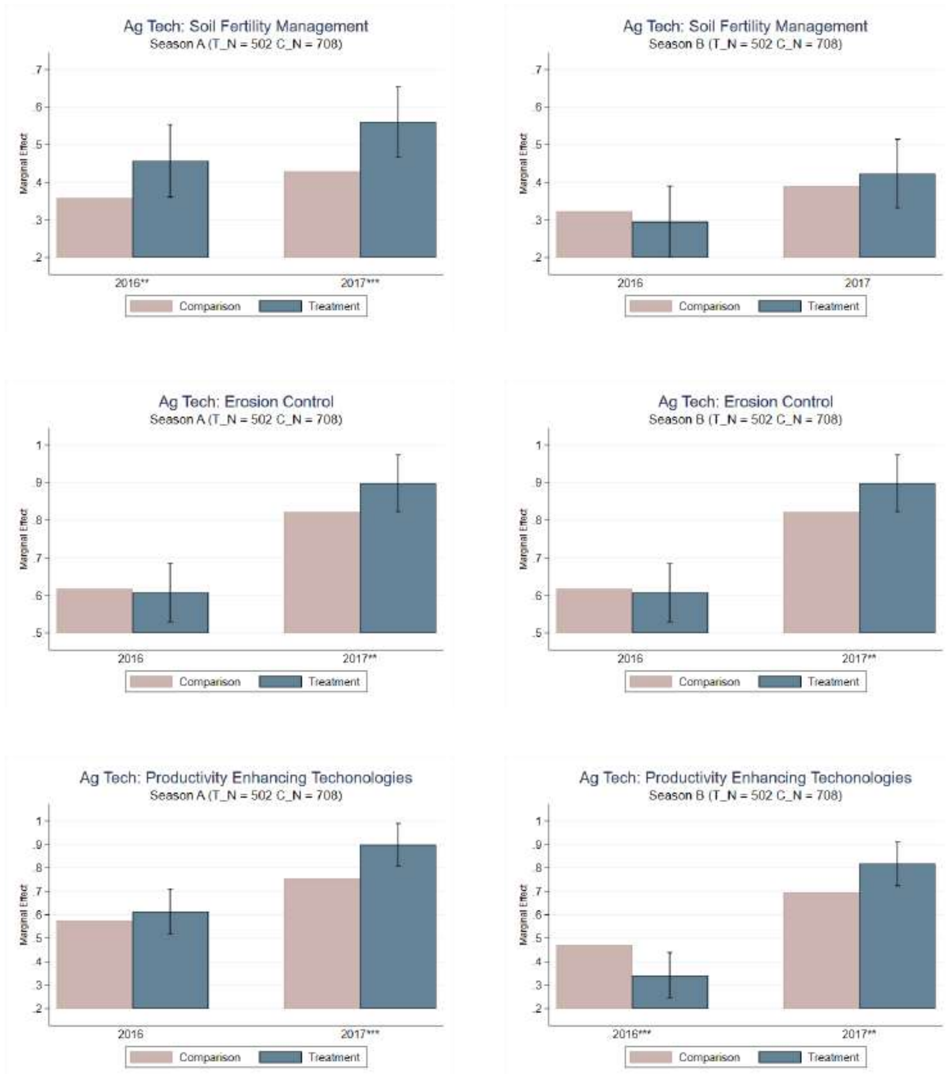
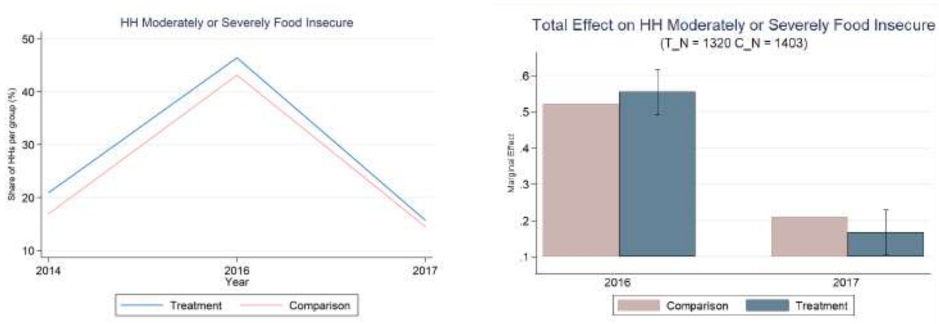


Figure 41: Correlation with the Use of Agricultural Technologies



C.5 Non-agricultural outcomes (food security and banking behavior)

Figure 42: Trends in Food Security Status



Change in Household Food Security Status

Figure 43: Trends in Financial Access and Behavior