

One Acre Fund

Quality of Life Study in Kenya and Rwanda: Year 2 Results



January 2018

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Special thanks to The MasterCard Foundation and The Small Foundation for their generous support in helping to make this study possible.



**The MasterCard
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EXECUTIVE SUMMARY

For years, One Acre Fund has rigorously tested the impact of its program on harvest yields and profits of participating farmers. However, questions remained on the ways in which the program was impacting other facets of farmers' lives. For example, we wanted to know: In what ways were farmers investing any extra income? Do these investments lead to better life prospects? How is the program affecting aspects like health, education, and nutritional status?

To better understand the impact on farmers' lives in a more holistic manner, in 2015 One Acre Fund initiated a "Quality of Life" study. This longitudinal study is currently following cohorts of One Acre Fund farmers in both Kenya and Rwanda (the largest country programs) and examining how their outcomes across a broad section of their lives – including health, education, nutrition, and financial literacy – change over time compared to changes which occur for a control group in a similar adjacent area. In addition to this **differences-in-difference study** design, we are using **propensity score matching** to control for any observable differences between the program and control groups. Both techniques will help us mitigate selection bias that comes from comparing farmers who self-selected into the program with those who have not.

Year 1 Results. One Acre Fund produced the [results from Year 1](#) of the study for Kenya and Rwanda. After one year of program participation, One Acre Fund farmers saw a **significant increase in agricultural productivity and decreases in hunger relative to control farmers in both countries** (although lower impact was seen in Rwanda, likely due to poor bean seed germination). This translated into **an increase in livestock asset accumulation** by Kenyan farmers, although not in Rwanda, probably due to the lower harvest. Surprisingly, we did not see much increase in education outcomes for the children in One Acre Fund households. In Kenya, this was likely partly because baseline educational attendance was already quite high. Although there was **no change in consumption patterns in Kenya**, in Rwanda, survey respondents reported an **increase in their total consumption in the past two weeks as well as one year** as compared to control farmers. Perhaps due to the increased agricultural productivity, One Acre Fund farmers in Kenya and Rwanda also reported **relying less on non-agricultural income streams over the study period**, as compared to control farmers. A **higher share of children in One Acre Fund households were reported to be consuming nutritious food items** such as milk (in Kenya) and fish and meat (in Rwanda). The Year 1 study was very useful in helping us understand our farmers better and improve our services. For instance, we have recently galvanized our focus on nutrition programming to move the needle beyond simply having more food towards also producing more nutritious food.

Year 2 Challenges. Our ability to programatically achieve and rigorously measure program impacts depends on a variety of external factors. In 2016, the second year of the study, we had some unique challenges that affected both our program's ability to generate impact and this study's ability to detect impact, across both Kenya and Rwanda.

1. **2016 Drought (Kenya):** In 2016, precipitation during the short and long rains growing seasons in Kenya was well below average, especially in the Arid and Semi Arid Land (ASAL) areas. This severe drought had an adverse effect on crop yields. Busia, the site for this study, was particularly badly hit from the drought, and suffered from a large decrease in average maize yield per acre. In the event of a drought, the program's ability to influence farmers' lives was limited, as compared to non-drought years when impact is generally much higher. Using better inputs and planting practices are simply not enough to fully insulate farmers from such large weather shocks. In such a year, even though One Acre Fund

clients in Busia saw better harvest outcomes than non-clients (and also their own baseline measures), it was not enough to cushion them from the drought completely, and they were worse off than other years when they were a part of the program and rainfall patterns were better.

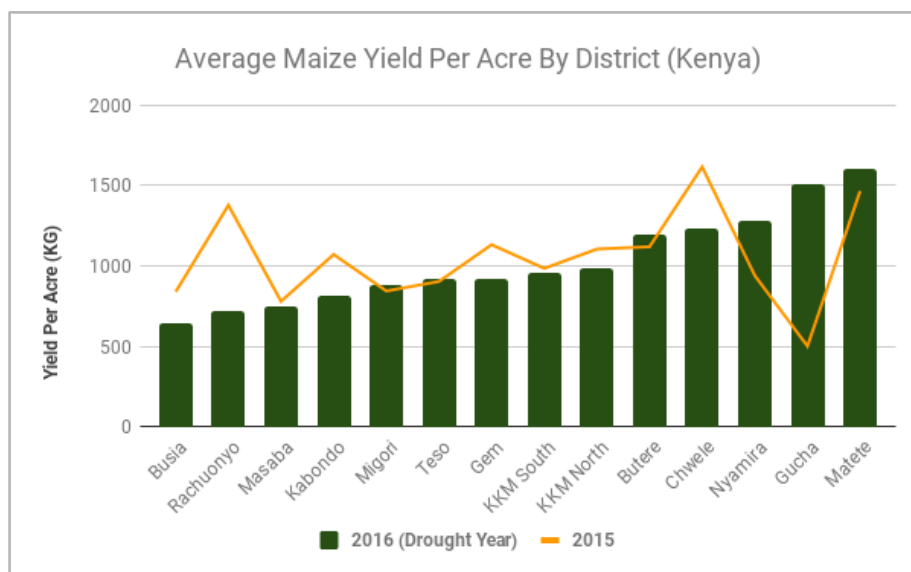
2. **Violation of Parallel Trends Assumption (Rwanda):** Our qualitative analysis (interviews with village chiefs and farmers) in study areas in Rwanda revealed that treatment and control sites faced dissimilar external shocks between 2016 and 2017, which could have caused varying impact on the quality of life outcomes for these two sites. Treatment sites were more likely to have faced drought and pest problems than control sites. On the other hand, control sites had more market access and public health programs from other NGOs than treatment sites in the past two years. Essentially, one of the basic tenets for carrying out a difference in difference evaluation, the parallel trends assumption (that any external shock affects both groups in the same direction and similar magnitude), may have been violated.
3. **Program Attrition (Rwanda):** In the study design, we had anticipated the likelihood of program attrition (both from the study as well as the program) over the four-year study duration. However, in Rwanda, program attrition has been relatively larger than we had foreseen. Around 41% of One Acre Fund farmers did not rejoin the program in the second year of the study. (This compares to Kenya's attrition of 29%). Traditionally, in Rwanda a large proportion of A season clients do not rejoin in the B season, when beans are the main crop, to which farmers do not apply fertilizer. As the baseline was carried out in the A season, and the Year 2 study was carried out in the B season, some attrition was expected. Combined with the poor bean germination in the baseline year, its seasonal character contributed to much larger attrition in Rwanda compared to Kenya.
4. **Government Permissions (Rwanda):** To measure child nutrition, we take physical weights, height, and middle upper arm circumference (MUAC) measurements of all children of five years of age and below in the households covered, to better understand the nutritional status of children. This year, due to government restrictions, we were not able to collect measurements for children in our sample in Rwanda, and will likely not get such permissions for coming years as well. In addition, we are facing difficulties in getting permission this year to even collect the non-anthropometric data.

Considering the violation of the parallel trends, difficulty obtaining government permissions to collect certain types of data, and the high level of attrition, we strongly believe that the costs of the study no longer outweigh the benefits and are recommending discontinuing the study in Rwanda. However, we will continue to mine the extensive qualitative data we collected in this past year for insights.

Year 2 Results. In the second year of the study, we found weak increases in maize yields per acre for One Acre Fund farmers in Kenya, and no measureable gains in Rwanda. These results are in sharp contrast with the findings in the first year of the study, when we saw much higher increases in agricultural productivity. However, in light of the 2016 drought in Kenya and the small sample size due to attrition in Rwanda, the decrease in agricultural impact between Years 1 and 2 of the study is not surprising.

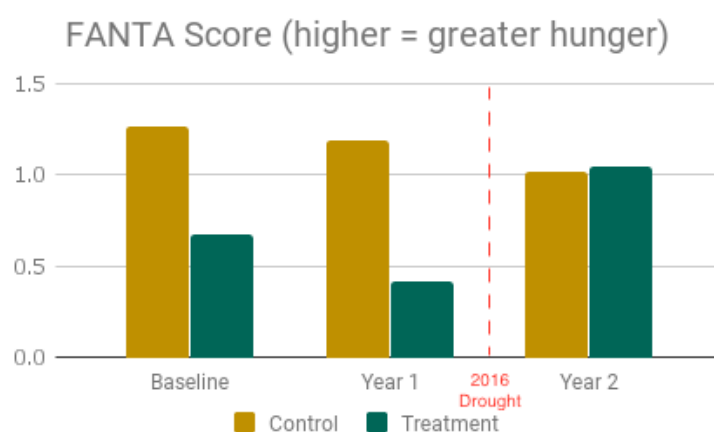
First and foremost, the link in the theory of change is impact on agricultural practices and yields for One Acre Fund farmers. When we find weak impact on the first link itself (either due to external realities such as drought, or study design issues such as parallel trends violation or attrition), it is very unlikely that we will be able to have much impact on other quality of life outcomes that would take place as a result of the higher harvests.

Graph 1: District-Wide Maize Yield Performance in Kenya in Drought and Non-Drought Years



Surprisingly, **One Acre Fund farmers in Kenya and Rwanda self-reported a greater increase in hunger from baseline than control farmers**, and in Kenya there was also a greater reduction in amount of maize remaining during hunger season since baseline compared to controls. Given the better yield outcomes in Kenya (both verified by farmers and our own physically measured estimates) than control farmers, it is unconvincing that One Acre Fund farmers actually faced more hunger than control farmers. It is possible that One Acre Fund farmers who had gone through one season with bumper harvest and reduced hunger now **felt (and therefore self-reported) they were worse off than before in the face of weather shocks and food scarcity**.

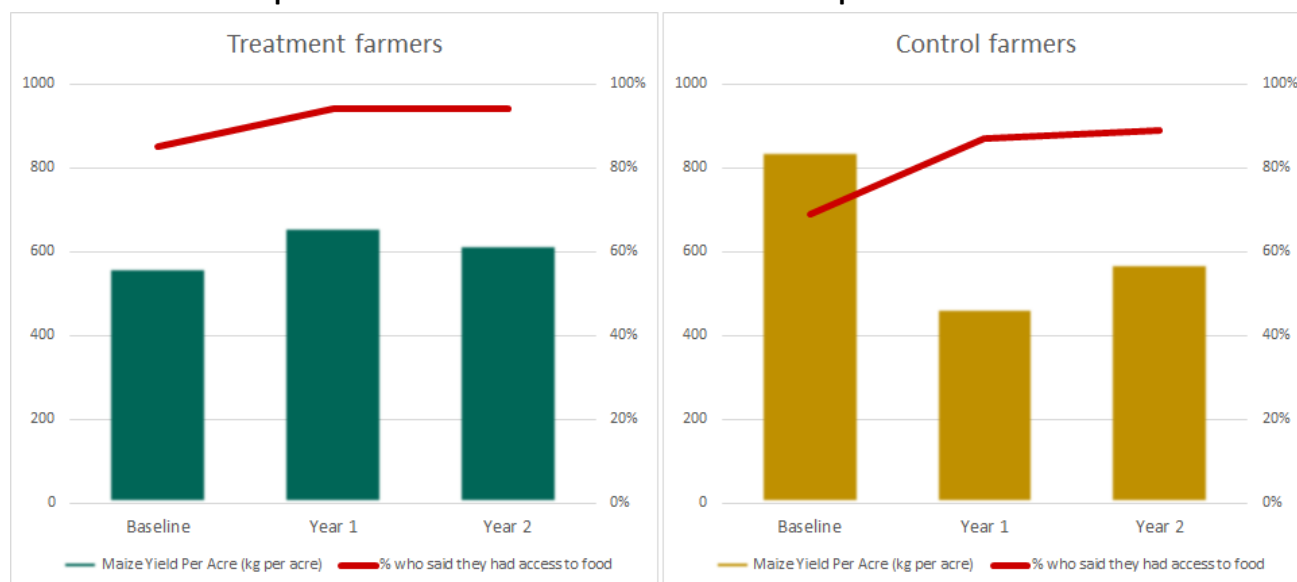
Graph 2: Trends in FANTA Score in Kenya



In Rwanda, we saw an increase in instances of treatment farmers reporting hunger due to lack of resources, relative to controls. This is contradictory to our findings from other studies in Rwanda where veteran farmers reported higher food security than newly enrolled farmers. Although One Acre Fund farmers reported an increase in their food security compared to the baseline, it was not as much as the increase reported by control farmers. However, we believe there is a bias with controls' reporting in the baseline year. Theoretically, food security indicators should **increase** with higher harvest; however, in the case of control farmers they are going

in the opposite direction (see the trends among control farmers between baseline and Year 1 in the graph below). We hypothesize that during the baseline collection, without any trust built with the enumerators, the control farmers might have felt compelled to exaggerate their hunger situation expecting potential aid from One Acre Fund or exaggerated their harvest to avoid any embarrassment in front of strangers. As our data collectors developed some rapport with control farmers through their second and third visits, they might have opened up and provided more accurate data.

Graph 3: Trends in Access to Food in Rwanda Compared to Maize Yield



In Year 2, unlike Year 1, we found no impact on any assets owned by the farmers (total, physical, livestock, and financial) in both countries. However, it seems that the **gains made by One Acre Fund farmers in Year 1 (the good agricultural year) were helpful in the tiding through the difficult drought period**. The impact on increases in livestock ownership for One Acre Fund farmers in Kenya in Year 1 disappeared in the succeeding year. We hypothesize that One Acre Fund farmers may have sold some of their livestock assets to cope with the drought shock, meaning that the first year of program participation could have promoted resilience.

In Year 2, **One Acre Fund farmers in Kenya reported a decrease in their self-reported income** over the past month at the time of the survey (before harvest and during the hunger season). Cash income for farmers is usually lumpy and unpredictable, and the timing of the survey also matters as occupations can vary with seasons. The most substantial driver behind the decrease in income was the decrease in wages. Our qualitative analysis reveals that **farmers do not view working for wages as a preferred method for earning money** due to the hard physical labor involved and very little monetary returns. Given these insights, it is not surprising that One Acre Fund farmers in Kenya, after experiencing an increase in agricultural profits in 2015, were less inclined to sell their labor to other farmers, whereas control farmers continued relying more on daily wages due to low agricultural productivity (especially in the event of the 2016 drought). This likely accounts for the reduction in income for One Acre Fund farmers during the hunger season.

Again, as with Year 1, farmers in both Kenya and Rwanda continued to be seen as **“leaning away” from non-agricultural businesses** as compared to control farmers. This is probably because they are finding **agriculture more profitable than other sources of income**. The qualitative analysis reveals that an increase in agricultural

profit does not necessarily provide an impetus to non-agricultural businesses, and the relationship is not as linear as we may have earlier believed. Most participants reported to prefer reinvesting agricultural profit back into farming (by increasing acreage, inputs, etc.) rather than into businesses. Additionally, farming and 'business' are highly interlinked and should not be studied as competing ways of earning an income, but instead as income sources that can in many cases go hand in hand. Many of the preferred businesses for the participants are derived from agriculture – for example, selling food grains and vegetables grown on their land.

As we go further down the casual chain for impact, it becomes increasingly difficult to have any impact in a poor harvest year such as we saw in Year 2. Given this, in Year 2, we see minimal or no impact on outcomes related to child education, consumption, and health or other exploratory areas such as women's economic empowerment.

We had hoped that the second year of the study would build on and deepen the strong quality of life impacts observed in the first year. However, unfortunately we saw an unprecedentedly poor agricultural year and had other study design issues and therefore did not find an increase in these secondary effects. However, we do have some evidence that program participation may have helped to cushion the blow of a difficult harvest year for treatment farmers in Kenya. We are very interested to see what the results from Year 3 in Kenya bring, as we know that agricultural season was much stronger, and One Acre Fund harvest impacts rebounded to their previously high levels.

REPORT

Purpose of Study

The ultimate goal of One Acre Fund is to reduce poverty and improve the quality of life for the farm families we serve¹. We have a growing body of evidence showing that One Acre Fund participation contributes to an increase in both yield and farm profit. We know less about how this translates into meaningful changes in farmers' lives and how the impact of our program may vary with seasonal fluctuations and other external shocks.

The central purpose of our Quality of Life Study is to understand and assess our impact on farmers' lives more holistically. This study is focused on the One Acre Fund programs in Kenya and Rwanda. We intend to investigate secondary program impacts, such as spending on education, health and hunger outcomes, and purchase of productive assets, through this longitudinal, multi-country study.

Methodology

Geographic Coverage and Selection

Our goals for selecting a study design were to identify a control group which: (1) looks similar to our farmers in terms of difficult-to-observe characteristics like motivation and risk (i.e. to avoid the "selection bias" problem when choosing a control group that did not self-select into the program), and (2) operates in a similar environment to our program farmers. These characteristics are important for tracking groups over long periods of time. For example, if a non-governmental organization providing nutrient supplements were to move into one area, it would create challenges for our study because it would be more difficult to attribute any changes in health outcomes to the One Acre Fund program.

For these reasons, we have selected the control farmers from an area bordering where our program operates. This helps us mitigate spillover, while ensuring a similar agro-ecological and social service environment. In Kenya, the study was conducted in the district of Busia, and in Rwanda, in the district of Ngororero. The sites were chosen as they fulfilled a set of predetermined criteria, such as being a relatively new program site, being representative in terms of agro-ecological conditions of typical program areas, not being a trial site, and having a cluster of sites around the area without any program intervention to serve as the controls which are separated with an arbitrary border. For complete details on how the sites were chosen in Kenya and Rwanda, please refer to Annex B.

Study Design

This report presents the results from the third round of data collection in Kenya and Rwanda (baseline, Year 1, and Year 2). We have pursued a **difference-in-differences approach** to study changes in the outcomes of interest. The control farmers were selected from just across the program boundary with very similar characteristics to One Acre Fund farmers. At the baseline, we found some differences between One Acre Fund and the control farmers. Compared to control farmers, One Acre Fund farmers were more educated, more likely to be married, had slightly older spouses, and had larger families, amongst other differences. To control for these differences, we undertook **propensity score matching** to ensure our control groups were adequately comparable to the treatment groups. For a complete overview of our matching strategy and

¹ For a detailed description of the program in Kenya and Rwanda, please refer to Appendix A.

approach, please refer to Annex D. Please refer to Annex C for a complete list of possible risks and steps taken to mitigate these risks to the extent possible.

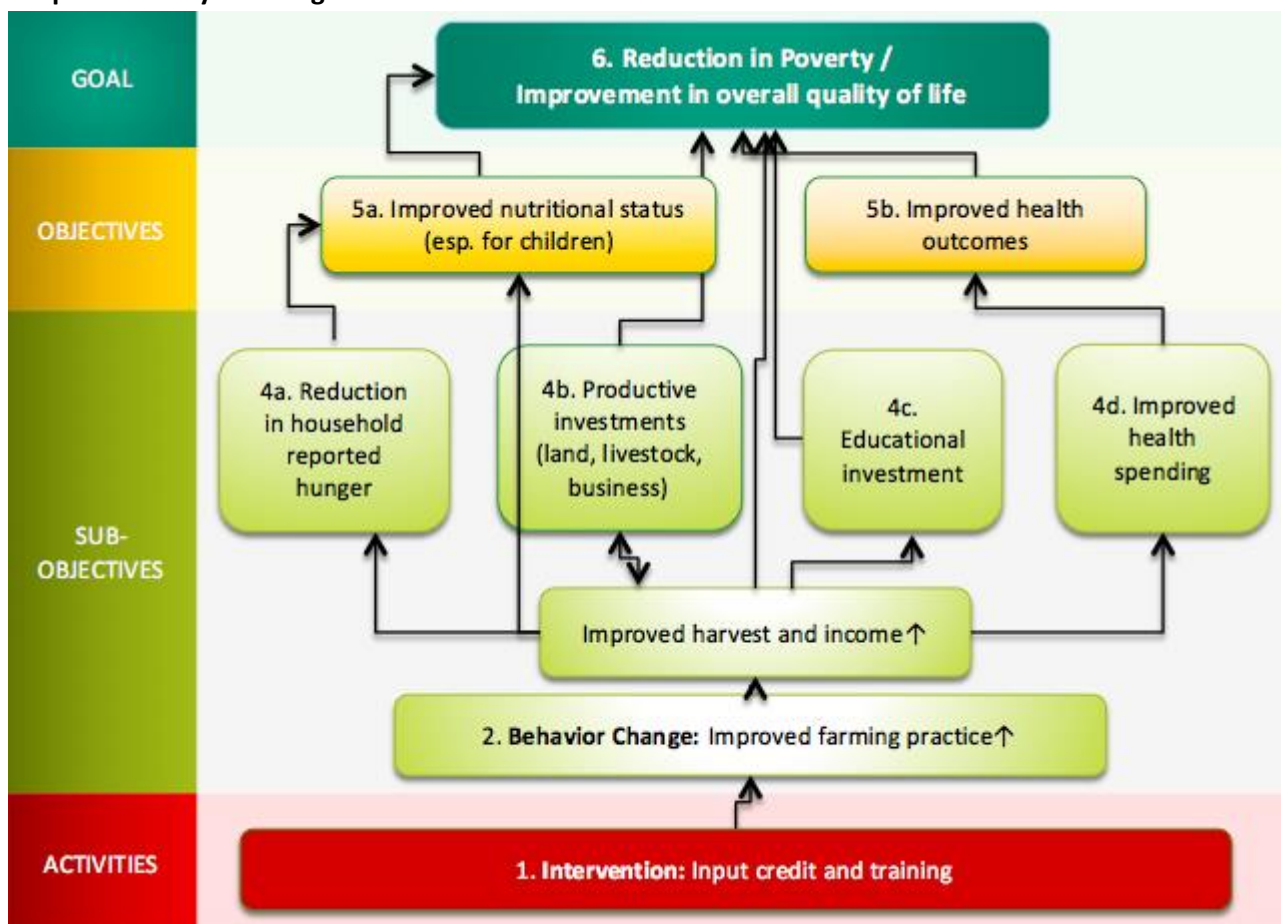
Note on Presentation of Analysis

Since we are presenting the results from several hypotheses in this report, for ease of presentation, we will often refer to the difference in difference results (i.e. the change noticed in One Acre Fund farmers in comparison to control farmers over the period of time from the baseline to the follow up round) interchangeably with “impact.” We have reported differences that are statistically significant at $p < .05$. This means there is less than a 5% chance that these differences would be caused by chance.

Context for Study

As per our pre-established analysis plan, we hypothesized that One Acre Fund program participation would have some impact on agricultural productivity, education expenditures, and hunger, based on our prior data collection efforts and analyses. We were also interested in understanding how that impact would translate into better dietary diversity, assets accumulation, financial education, gender dynamics, and nutrition. Below is a simplified visual of what is known as our ‘theory of change,’ showing the path from what we do (our program components) to achieving this long-term impact goal.

Graph 4: Theory of Change



In the first year of the study, when there were no major weather shocks, we found significant increases in agricultural productivity and decreases in hunger relative to control farmers in both countries (although impact was lower in Rwanda, likely due to poor bean seed germination). This translated into an increase in livestock asset accumulation by Kenyan farmers (although not in Rwanda, probably due to the lower harvest). Surprisingly, we did not see much increase in education outcomes for the children in One Acre Fund households. In Kenya, this was likely partly because baseline educational attendance was already quite high. Although there was no change in consumption patterns in Kenya, in Rwanda, we saw an increase in the total consumption in the past two weeks as well as one year, as compared to control farmers. Perhaps due to the increased agricultural productivity, One Acre Fund farmers in Kenya and Rwanda also reported relying less on non-agricultural income streams over the study period, as compared to control farmers. A higher share of children in One Acre Fund households were reported to be consuming nutritious food items such as milk (in Kenya) and fish and meat (in Rwanda).

Our ability to programmatically achieve, and rigorously measure, program impacts depends on a variety of external factors. However, in 2016 (the second year of the study), we had some unique challenges that affected both our program's ability to generate impact and this study's ability to detect impact, across both Kenya and Rwanda.

1. **2016 Drought (Kenya):** In 2016, precipitation in the short and long rains seasons in Kenya was well below average, especially in the Arid and Semi Arid Land (ASAL) areas. This severe drought which had an adverse effect on the yield of crops. Busia, the site for this study, was particularly badly hit from the drought, and suffered from a large decrease in average maize yields per acre. In the event of a drought, the program's ability to influence farmers' lives was limited, as compared to non-drought years where impact is generally much higher. Using better inputs and planting practices are simply not enough to fully insulate farmers from such large weather shocks. In such a year, even though One Acre Fund clients in Busia saw better harvest outcomes than non-clients (and also their own baseline measures), it was not enough to cushion them from the drought completely, and they were worse off than in other years when they were part of the program and rainfall patterns were better.
2. **Violation of Parallel Trends Assumption (Rwanda):** Our qualitative analysis (interviews with village chiefs) in study areas in Rwanda revealed that treatment and control sites faced dissimilar external shocks between 2016 and 2017, which could have caused varying impacts on the quality of life outcomes for these two sites. Treatment sites were more likely to face drought and pests than control sites in 2017. On the other hand, control sites had more market access and public health programs from other NGOs than treatment sites in the past two years. Essentially, one of the basic tenets for carrying out a difference in difference evaluation, the parallel trends assumption (that any external shock affects both groups in the same direction and similar magnitude), may have been violated.
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- Considering the violation of the parallel trends, difficulty obtaining government permissions to collect certain types of data, and the high level of attrition, we strongly believe that the costs of the study no longer outweigh the benefits, and are recommending discontinuing the study in Rwanda. However, we will continue to mine the extensive qualitative data we collected in this past year for insights.

2016 Drought in Kenya

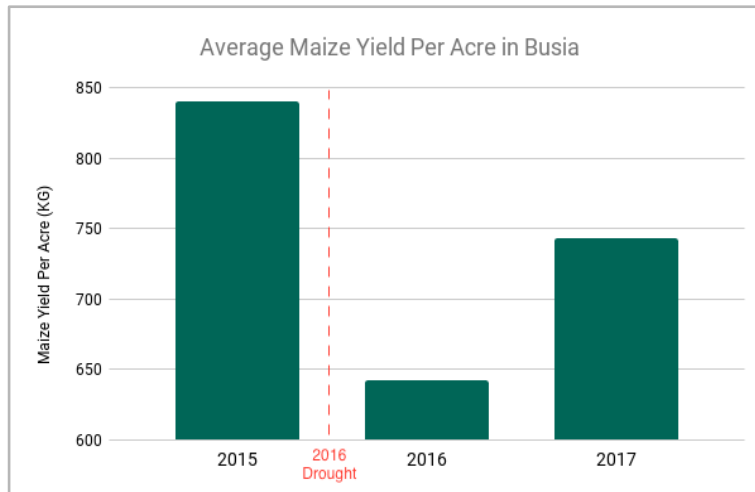
Major rainfall patterns in Kenya can be classified into long rains (March, April, and May) and short rains (October, November, and December). After a poor performance of the 2016 long rains season, the 2016 short rains also failed. This rainfall shortage was especially acute in the Arid and Semi Arid Land (ASAL) areas of Kenya. As a result, Kenya faced a severe drought, which had an adverse effect on the yield of crops planted during this season. Maize harvests in that season were much lower than usual, and as per UNICEF estimates, the food insecure population more than doubled during this period².

Given that we work with smallholder and subsistence farmers who usually grow their own food, the drought stress would have had an adverse impact on the food security of our client households well into 2017 (possibly a consequence of both minimal or no harvest remaining from the 2016 season, and increasing market prices of food).

Figure 2 below shows the average maize yield per acre physically measured by One Acre Fund teams for non-clients in 2015 (normal agricultural year) and 2016 (drought year) across some districts where One Acre Fund operates. The graph reveals that maize yields in 2016 were lower than the 2015 yields in most of the districts in Kenya (with the exception of a few districts, which were not affected by the drought). Additionally, in absolute terms, Busia was one of the lowest harvest districts in the Kenya program in 2016 (see Graph 6), which makes it, unfortunately, less representative of the program overall.

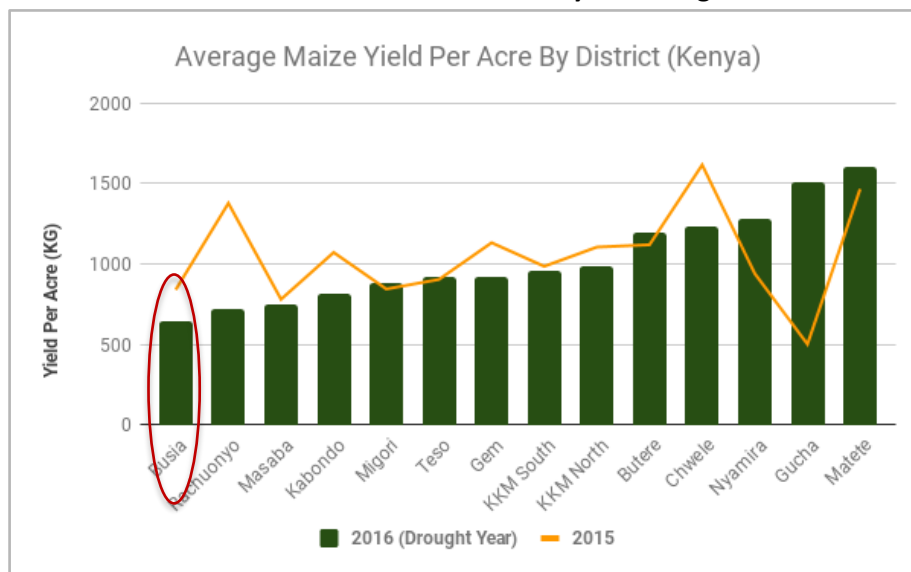
Graph 5: Average Maize Yield Performance in Busia in Drought and Non-Drought Years

² Please see https://www.unicef.org/kenya/emergency_19640.html for details.



Using better inputs and planting practices are simply not enough to insulate farmers from large external agricultural shocks. In such a year, even though One Acre Fund clients in Busia faced better harvest outcomes than non-clients (and also their own baseline measures), it was not enough to cushion them from the drought completely, and they would be worse off than other years when they were a part of the program and rainfall patterns were better.

Graph 6: District-Wide Maize Yield Performance in Kenya in Drought and Non-Drought Years



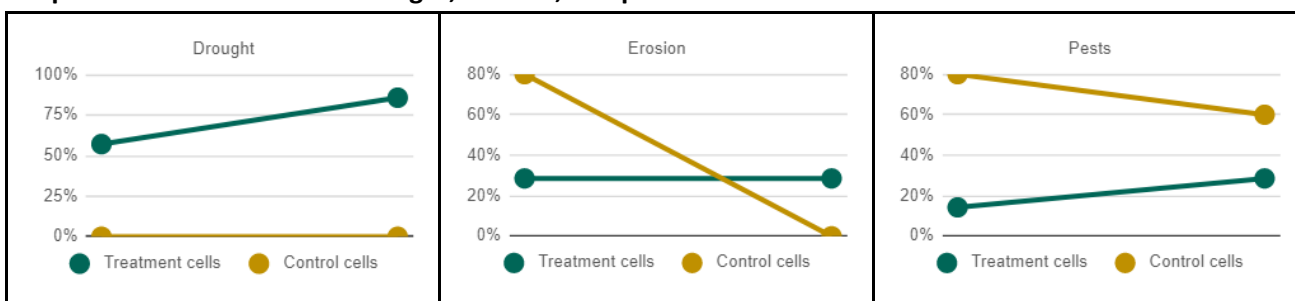
Violation of Parallel Assumption in Rwanda

We interviewed the village chiefs from the study sites in Kenya and Rwanda to understand both positive and negative external shocks being faced in the area. Although we have chosen geographically adjacent and highly similar areas to serve as the control areas for this study, it is possible that they faced different external realities that are outside of our scope to control. In total, we interviewed 12 chiefs from treatment and control sites in Rwanda and 12 chiefs from study sites in Kenya. In-depth questions were asked on three main areas: natural shocks, operations of non-One Acre Fund agricultural programs, and other programs enhancing quality of life related areas. The results show that in between 2016 and 2017, treatment and control sites in Rwanda faced disparate external shocks, which could have caused varying impacts on the quality of life outcomes on the

populations in these two sites. However, we found no such exceptional differences between treatment and control sites in Kenya. Essentially, one of the basic tenets for carrying out a difference in difference evaluation, the parallel trends assumption (that any external shock affects both groups in the same direction and similar magnitude), may have been violated in Rwanda.

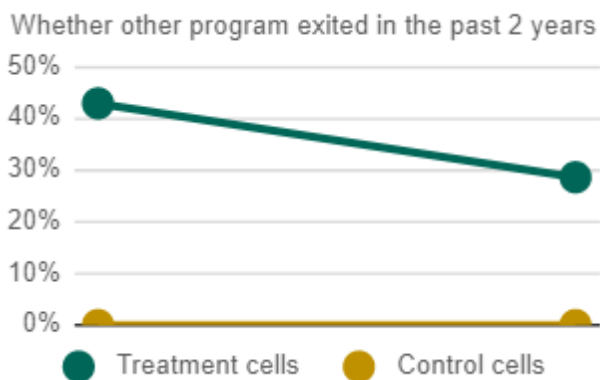
Natural shocks: In 2017, natural shocks such as drought, pests, and erosion affected the treatment sites in Rwanda more heavily than control sites compared to 2016, which might have diminished the program effect. For example, treatment sites were more likely to face drought and pests than control sites in 2017. This difference between two sites was also testified by farmers we interviewed. Farmers in control sites were satisfied with good yields in 2017, whereas farmers in treatment sites reported bad harvests, attributing to pest and difficult weather.

Graph 7. Different trends of drought, erosion, and pests between treatment and control sites in Rwanda



Existence of non-One Acre Fund programs: One Acre Fund doesn't operate in a vacuum – we commonly work in rural communities where other NGOs come and go. Between 2016 and 2017, there were no other agricultural programs working in our control sites. However, the number of other agricultural programs in treatment sites decreased in 2017. This might have narrowed the gap in compliance with good agricultural practice between two groups. On the other hand, control sites had more market access and public health programs from other NGOs than treatment sites in the past two years.

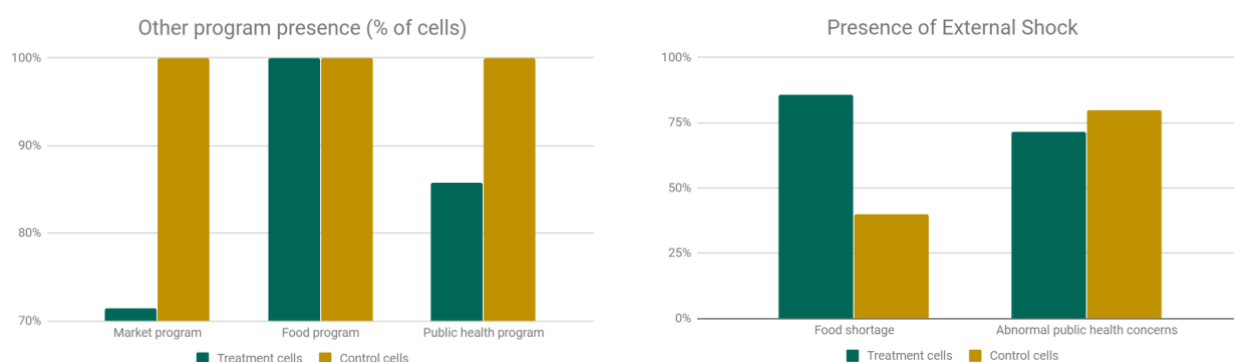
Graph 8: Decrease in the number of other agricultural programs in treatment sites, Rwanda



Other quality of life influencing programs and shocks: Food shortages were reportedly more serious in the treatment sites, and abnormal public health-related events affected control sites more than their counterparts

in the past two years. Moreover, the control sites have more market and public health-related program presence than treatment sites. These differences might have affected the program’s effects. While more abnormal public health-related events, such as a measles outbreak, in the control sites might have exaggerated the program impact on health, the existence of other programs in control areas might have diminished our ability to detect the program impact on other quality of life indicators.

Graph 9: Results from Village Chief Surveys in Rwanda



Year 2 Results

Agriculture

In the second year of the study, we found weak increases in maize yield per acre for One Acre Fund farmers in Kenya and no measureable gains in Rwanda. Kenyan One Acre Fund farmers self-reported an impact of 86.9 kg per acre on their maize harvest, and we found no statistically significant impact in Rwanda. These results are in sharp contrast with the findings in the first year of the study, when we saw much higher increases in agricultural productivity.

In light of the 2016 drought in Kenya, the decrease in agricultural impact between Years 1 and 2 of the study is not surprising. The absence of any impact in Rwanda in Year 2 could be attributed to the small sample size being studied due to the large attrition from the program, which reduced the power of the study to detect statistically significant differences. Maize and bean yields per acre had positive coefficients (Table 1). Moreover, bean yields per acre had statistical significance at the ten percent level, which we do consider in this report as a significant result, but this might be the indication of small sample size hindering us from finding significant results. Furthermore, considering that treatment sites in Rwanda experienced higher incidences of

natural disasters (drought, heavy rain, and pests) compared to control sites in Year 2, any impact of the program would be masked against the comparison group, which did not face such unfavorable conditions for agriculture. The trends analysis (Graph 10) shows that, despite the adverse environment, One Acre Fund farmers performed slightly better than control farmers and even better than their baseline year, which is also backed up by the qualitative research.

"I have planted only 2 kg of maize and harvested 60 kg of dry maize without counting what we ate when they were still wet. Tubura inputs (Tubura is local name of One Acre Fund in Rwanda) helped considerably to increase yield and productivity. Those who didn't use Tubura inputs are not having good harvests; for this reason, other neighbors are interested in adopting fertilizer." (Interviewee, client, male, 23, Bweramana cell, Rwanda)

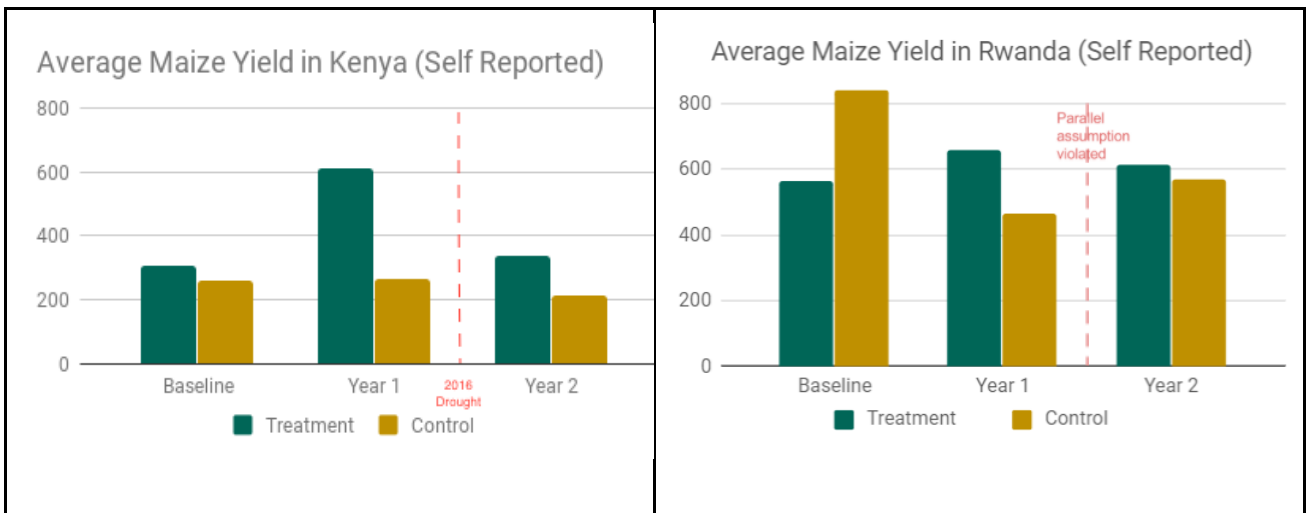
"Tubura practice, particularly planting in lines, has increased the productivity and we use less seeds than before." (Mixed sex focus group, Gatumba cell, Rwanda)

Table 1. Agricultural Outcomes - Difference in Change Over Time for One Acre Fund vs Control Farmers				
Outcomes of Interest	Kenya		Rwanda	
Year compared to the baseline	2016	2017	2016	2017
Total Maize Yield per Farmer (kg)	248.3***	-31.28	65.83***	168.6
Maize Yield Per Acre (kg per acre)	402.5***	86.99***	349.8***	463.1
Total Beans Yield per Farmer (kg)	N/A	N/A	41.53	-10.65
Beans Yield Per Acre (kg per acre)	N/A	N/A	326.3	417.0*
Total Area Cultivated (4 main crops)	0.304***	0.368***	0.025	0.034
% who evaluated good harvest (Maize)	44%***	-2.60%	-6%	4%
% who evaluated good harvest (Beans)	N/A		-10.1%**	1.24%
Difference in Physically Measured Harvest in Year 2 (kg per acre)				
(Not difference in difference)	638***	161.44**	27.6	28.6
Given introduction.	(Maize)		(Beans)	

***** p<0.01, ** p<0.05, * p<0.1**

Yield data relying on farmer recall can be subjected to bias, since farmers may not remember details accurately. Therefore, we also took physical measurement of harvests for a subset of participants in the study. In 2016, 262 farmers from the study area in Kenya participated in the harvest physical measurement, of which 163 were One Acre Fund farmers and 99 were control farmers. We found that on average, One Acre Fund farmers harvested 161.44 kg/acre more than control farmers. In Rwanda, we measured bean harvests, which was the main crop for the B season when the harvest survey was carried out. In total, 245 control and 274 One Acre Fund farmers participated in this physical measurement survey. Reiterating the results from the self-reported data, we found that although on average clients harvested 28.6 kg/acre more than control farmers, this result was not statistically significant.

Graph 10: Trends in Average Maize Yields (Self-Reported by Farmers)



The first and foremost link in the theory of change is impact on agricultural practices and yields for One Acre Fund farmers. When we find weak impact on the first link itself (either due to external realities such as drought, or study design issues such as parallel trends violation or attrition), it is very unlikely that we will be able to have much impact on other quality of life outcomes that would take place as a result of the higher harvests.

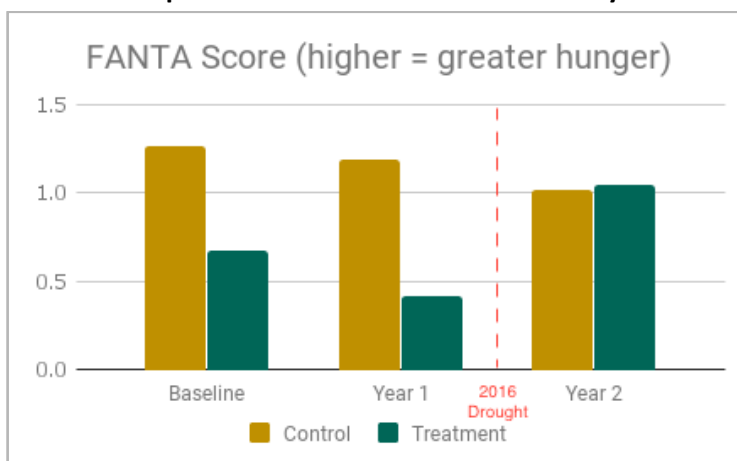
Hunger

Measurement: To measure hunger, we asked several questions to capture outcomes related to experiencing hunger, as well as the food intake and nutrition of the household. We have used USAID’s Food and Nutrition Technical Assistance (FANTA) Score to create an indicator for measuring hunger. The FANTA Score is a weighted average of the amount of scarcity of food, prevalence of sleeping hungry, and complete days spent with hunger. Farmers were also asked to describe the intensity of the hunger season they faced based on the frequency with which they went hungry. To measure dietary diversity of the household, we asked farmers to report all food groups listed that they had consumed in the last two days. The final dietary diversity score was compiled by aggregating all food groups consumed, which may potentially range from 0 to 11.

Results: Despite the drought, we found that One Acre Fund farmers in Kenya were able to have slightly higher maize yields as a result of program participation compared to the baseline. However, when compared to the previous year, they actually faced a severe reduction in their harvest, when they had reaped much higher benefits from the program. Although the drought affected all farmers, **it is possible that One Acre Fund farmers who had now gone through one season with reduced hunger felt that they were worse off than before in the face of food scarcity.**

This is reflective in some of the hunger results we observed from the data that were more subjective in nature. **One Acre Fund farmers in Kenya self-reported higher intensity of hunger** and there was a **significant increase in the percentage of One Acre Fund farmers who felt they had no food to eat due to lack of resources.** Given the better yield outcomes in Kenya (both verified by farmers and our own physically measured estimates) than control farmers, it is unlikely that One Acre Fund farmers actually faced more hunger than control farmers. However, it is possible that One Acre Fund farmers who had now gone through one season with bumper harvests and reduced hunger now **felt (and therefore self-reported) they were worse off than before in the face of weather shocks and food scarcity.**

Graph 11: Trends in FANTA Score in Kenya



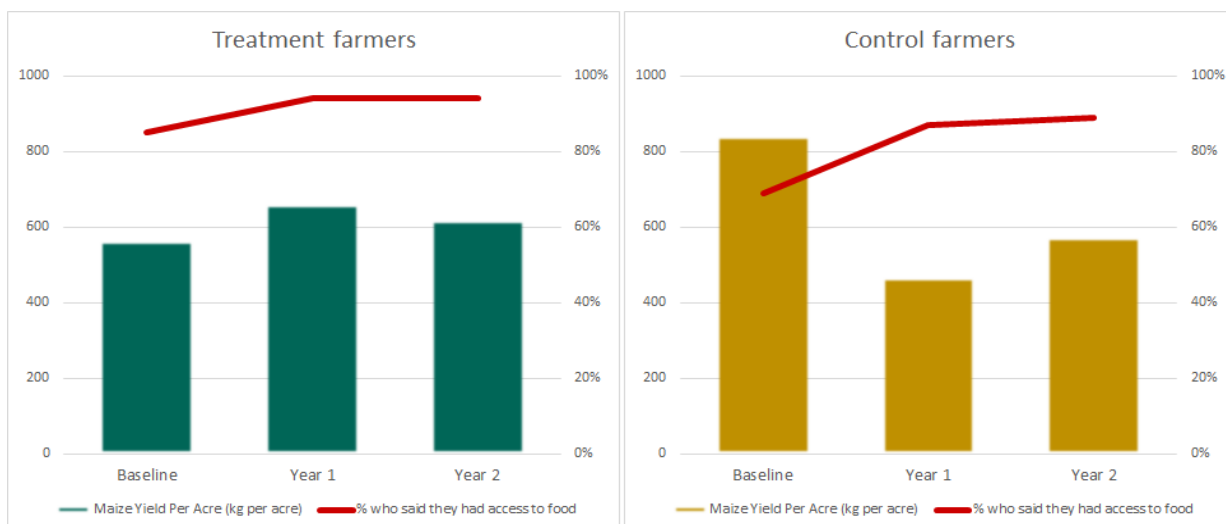
One Acre Fund farmers in Rwanda reported to have additional 12.97 kg of their maize harvest remaining per acre (Table 2), which is corroborated by the focus group and interview accounts.

"Now we harvest maize, eat, and sell the remainings later to buy health insurance and pay school fees" (Female focus group, Cyome cell)

"I am able to feed my grandchild and myself because of the harvests I have thanks to Tubura's products." (Interviewee, client, female, 42, Rusomo cell)

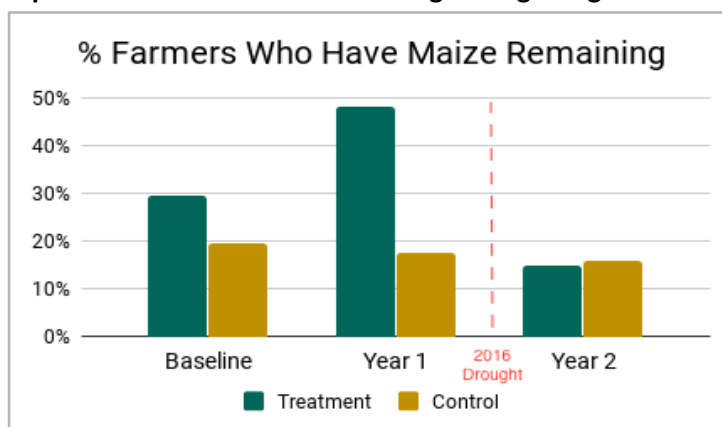
Oddly, One Acre Fund farmers also reported a significant increase in instances of no food to eat because of lack of resources, relative to controls. This is contradictory to the indicator of food remaining and also to our findings from other studies in Rwanda where veteran farmers reported higher food security than newly enrolled farmers, which is also statistically significant. Although One Acre Fund farmers reported an increase in their food security compared to the baseline, it was not as much as the increase reported by control farmers. However, we believe there is a bias with controls' reporting in the baseline year. At the baseline, a higher percentage of control farmers reported experiencing hunger (31%) than treatment farmers did (15%), whereas they reported higher yields on maize (840 kg/acre) and beans (669 kg/acre) than One Acre Fund farmers (562 kg/acre and 334 kg/acre respectively). Theoretically, even though food security indicators should increase with higher harvest, in the case of control farmers, they are going in the opposite direction. In Years 1 and 2, control farmers reported fairly consistent results on yields and hunger indicators considering external factors such as weather shocks. We hypothesize that during the baseline collection, without any trust built with the enumerators, the control farmers might have felt the need to exaggerate their hunger situation expecting potential aid from One Acre Fund, or their harvest to avoid any embarrassment in front of strangers. As our data collectors developed some rapport with control farmers through their second and third visits, they might have opened up and provided more accurate data.

Graph 12: Trends in Access to Food in Rwanda Compared to Maize Yield



Surprisingly, in Kenya we also found a reduction in the percentage of farmers who had maize remaining and total amount of maize remaining (in kg), which is a more objective measure of hunger. Given that yields were actually higher than the baseline for One Acre Fund farmers, one explanation for these results is that market prices for maize increased in the drought year. It is possible that **selling and consumption patterns of harvested maize changed drastically in the drought year**, given there wasn't enough maize to go through the hunger season and it may also have become more expensive to buy maize from the market, thus relying on their own grown maize more for the food in the earlier months right after the harvest.

Graph 13: Trends in Maize Remaining During Hunger Season in Kenya



In Rwanda, the program gains made on increasing dietary diversity in the first year of the study disappeared in the second year. The trends analysis shows that although clients' dietary diversity score increased compared to the baseline year, there was a higher increase for control farmers' score. The impact on control farmers dietary diversity might have been influenced by the external food program(s) in the control sites that were not present in the treatment sites.

Graph 14: Trends in Dietary Diversity Score in Rwanda

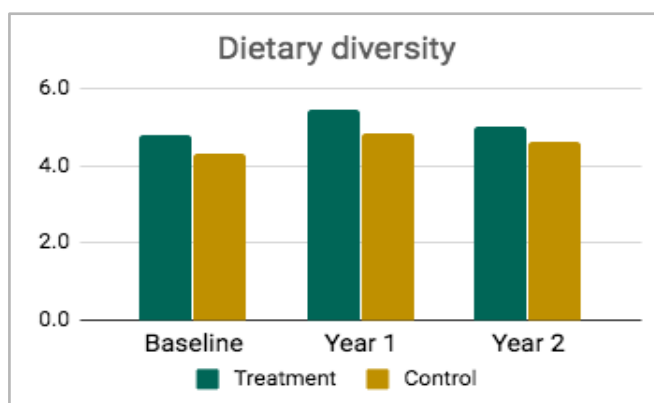


Table 2. Food Security - Difference in Change Over Time for One Acre Fund vs Control Farmers				
Outcomes of Interest	Kenya		Rwanda	
	2016	2017	2016	2017
Year compared to the baseline				
% who have maize remaining	18.1%***	-11.0%***	16.2%*	8.0%
% who have beans remaining	N/A	N/A	-8.7%**	0.0%
Total amount of maize harvest remaining (kg)	19.8*	-13.33***	9.193***	0.989*
Total amount of maize harvest remaining (kg per acre)	36.2	-32.74**	67.34***	12.97***
Total amount of beans harvest remaining (kg)	N/A	N/A	-0.701	-10.77*
Total amount of beans harvest remaining (kg per acre)	N/A	N/A	-10.22	-4.42
Dietary Diversity (higher score indicates a more diverse diet)	-3.60%	-0.111	0.481***	-2.30%
For the outcomes below a negative number indicates a positive program effect				
Percent reporting "severe hunger season" (reported they almost never had enough to eat)	-3.0%	4.70%	3.03%*	-0.64%
Months of reported hunger season	-0.39**	0.343	-22.0%	-0.09
FANTA Score (higher score indicates greater hunger)	-0.08	0.620***	0.0	0.16
% who had no food to eat because of lack of resources (in past 30 days)	3.80%	45.6%***	8.38%** *	7.88%**
% of households where a member slept hungry because there was not enough food (in past 30 days)	-10.5%**	11.7%*	-1.1%	-0.2%
% of households where a member went whole day and night without eating anything because there was not enough food (in past 30 days)	1.1%	4.7%	2.1%	2.0%
*** p<0.01, ** p<0.05, * p<0.1				

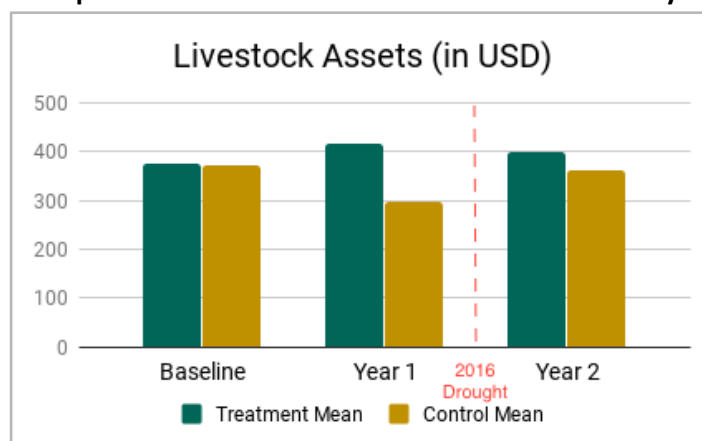
Assets

Background: The survey asked farmers to report on three categories of assets: (1) physical without house and land (such as furniture, radios etc.), (2) financial (value of money kept in savings, merry-go-round, cash), and (3) livestock. Farmers were asked to value each asset at the current value (the price they would be able to sell each item for today).

Results: Looking at Year 2 data, we see almost no impact on any of the categories of assets measured. It may seem that all assets held by farmers have remained static during the past two years. However, disaggregating asset values by year, we see some fluctuations in livestock assets in Kenya. In Year 1, we found programmatic impact on the value of total livestock owned by One Acre Fund farmers by almost \$75 as compared to control farmers. Looking at individual livestock responses, this had corresponded with an increase in the value of cows

owned by One Acre Fund farmers. However in the drought year, there was a decrease in value of livestock for One Acre Fund farmers and at the same time, control farmers were also able to recover some of their losses made in Year 1. One Acre Fund farmers may have sold some of their livestock assets to cope with the drought shock. It seems that the gains made by One Acre Fund farmers in the good agricultural year were helpful in the tiding them through the difficult drought period.

Graph 15: Trends in Value of Livestock Assets in Kenya



There has been no statistically significant impact on any of the three aggregated assets for One Acre Fund farmers in Rwanda for any of the two years in the study. Considering the low yield increase in the first year and violation of parallel trends in the second year, it is not surprising that we couldn't find any impact on asset accumulation in Rwanda.

Outcomes of Interest	Kenya		Rwanda	
	2016	2017	2016	2017
Year compared to the baseline				
Overall Consumption Value				
Total Assets Value (without house and land value) in USD	1479.8	-1158.7	24.41	18.58
Total Physical Assets Value (without house value) in USD	1100.7	-1094.9	11.22	0.0734
Total Financial Assets Value in USD	0.3	-5.6	5.9	11.39
Total Livestock Assets Value in USD	74.9***	35.4	15.67	9.624
*** p<0.01, ** p<0.05, * p<0.1				

Income

Total Income: After the first year of the study, we found that One Acre Fund farmers in Kenya reported a decrease in income of almost \$7 as compared to control farmers. In the second year, this decrease has doubled to almost \$14. Cash income for farmers is usually lumpy and unpredictable. The timing of the survey also matters as occupations can vary with seasons. This survey was taken during the hunger season and One Acre Fund farmers would have reaped the harvest impact over seven months before the survey. So, it is possible that any cash impact effects of the (slightly) increased harvest had dissipated by then.

The decrease in income in Kenya here is mainly driven by a decrease in wages, business profit, and income from selling grains for One Acre Fund farmers. The most substantial is the decrease in wages, which was mainly driven by an increase in wages for control farmers and a slightly smaller decrease for One Acre Fund farmers. On the other hand, there is no impact on total income in Rwanda. In the first year of the study we did find that One Acre Fund clients had increased their wage income slightly. However, this difference is no longer statistically significant in the second year of the study.

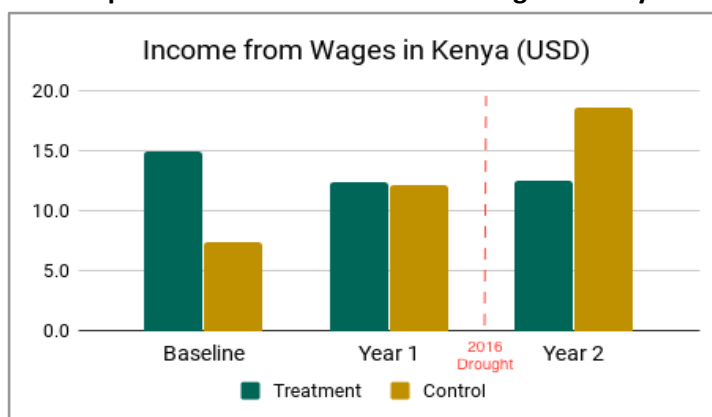
To understand farmers’ perspective on why they choose certain income strategies over others, we delved into this through the qualitative research using focus group discussions and in-depth interviews. We asked farmers in the study areas in Kenya to provide their thoughts on working for daily wages. There was strong consensus in the focus group meetings that working for casual wages is a non-preferred method for earning money. The participants reported that such work involves a lot of physical labor with comparatively smaller remuneration, and there was uncertainty tied with this because they might not get paid even after completing the work.

“I think if you get used to doing that kind of job (daily wages), you can never develop because you cannot get time to do your own things. You will be always on the road looking for the casual labor job, which has less payment with a lot of work.” (Female-only focus group, One Acre Fund clients, Eluche, Kenya)

“Working as a casual laborer is a very hard job. You can be given a very wide place to dig, but the payments are just peanuts. I hate that job.” (Female-only focus group, One Acre Fund clients, Eluche, Kenya)

Given these insights, it is not surprising that One Acre Fund farmers in Kenya, after experiencing an increase in agricultural profits in 2015, started moving away from daily wages and control farmers started relying more on daily wages due to low agricultural productivity (especially in the event of the 2016 drought).

Graph 16: Trends in Income from Wages in Kenya



Non-Agricultural Businesses: In both Kenya and Rwanda we see a higher share of One Acre Fund farmers “leaning away” from non-agricultural businesses as compared to control farmers. In Kenya, we do see a reduction in the number of new businesses and percentage of farmers with businesses as compared to control farmers. In terms of percentage of farmers reporting to receive more than half of their income through non-agricultural businesses, there has been a reduction of 28.3 percentage points in Kenya and 10.8 percentage

points in Rwanda. There are two forces driving these results; firstly, agriculture is getting more profitable than before. Therefore, its share in the total income of the household is now larger (and not always necessarily a decrease in non-agricultural businesses). Secondly, for a few One Acre Fund farmers, it may be possible that after finding more success in agriculture they are now more inclined towards that area and disinvesting from non-agricultural businesses.

The qualitative analysis in both countries shows us that an increase in agricultural profit does not necessarily provide an impetus to non-agricultural businesses and the relationship is not as linear as we may have earlier believed. Most participants reported to prefer reinvesting agricultural profit back into farming (by increasing acreage, inputs etc.) rather than into non-agricultural businesses. Those who did mention they would also invest agricultural profit into businesses, it was almost always related to investing half in farming and half in businesses. Rwandan farmers also reported to prefer reinvesting agricultural profit back into agriculture rather than businesses from another sector due to higher risk perceived. They mentioned feeling more comfortable reinvesting in agriculture because they are well familiar with it.

*"I cannot tell you that I would start doing commerce because I would not succeed at that. I do not have the skills to do that. I would invest it in an agricultural project because that is what I would know how to do."
(Interviewee, client, male, 50, Rusomo cell, Rwanda),*

*"If I have fantastic harvests and I am able to make some money from them, why would I not try some new things? You could buy a piglet; you could also buy some chickens to breed. All those things would be a good step from the money you got from farming. Many people do it."
(interviewee, client, male, 23, Bweramana cell, Rwanda)*

"I settled in farming and I began with half an acre. I later planted an acre of maize and managed to harvest 13 bags of maize, which helped in paying my children's school fees, and the remainder was reserved for domestic consumption. This has greatly encouraged me to stick to farming due to the huge profits gained. I also plant and sell the Sukuma Wiki, being supplied by One Acre Fund, and the income earned is used to cater for my domestic needs." (Female-only focus group, One Acre Fund clients, Busire, Kenya)

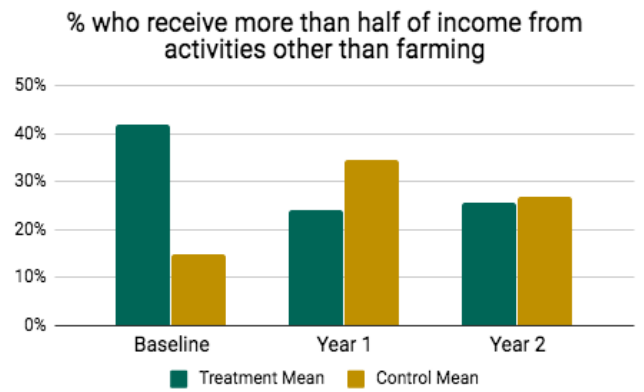
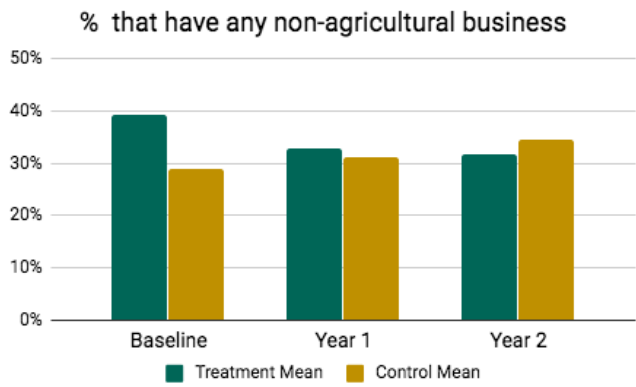
(In response to question on what are the most attractive business) "It's rearing livestock because it brings about good and quick returns." (Female-only focus group, Karambo cell, Rwanda)

Additionally, farming and "business" are highly interlinked and are not necessarily competing ways of earning an income – instead, they are viewed as income sources that can in many cases go hand in hand. Many of the preferred businesses for the participants are derived from agriculture – for example, selling food grains and vegetables grown on their land.

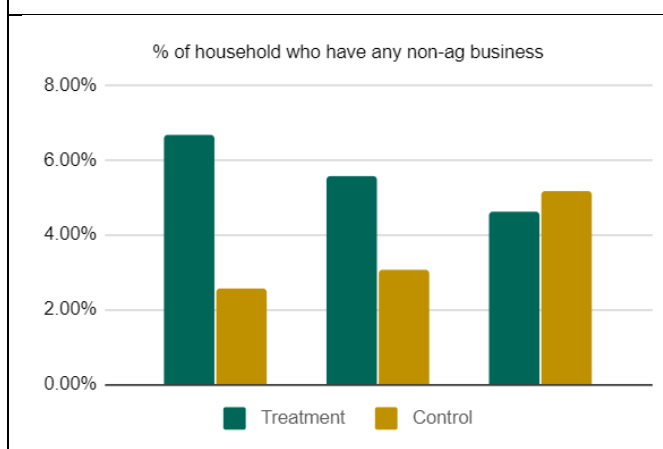
"If I get more harvest, I can sell some at a good price and use the money to buy something that will be productive like chickens. I will put that money in business and make it grow. I will put back in farming by leasing some land and preparing for the next season." (Female-only focus group, One Acre Fund clients, Eluche, Kenya)

Graph 17: Ownership of non-agricultural businesses in Kenya

Graph 18: Percentage who receive more than half of their income from non-agricultural activities in Kenya



Graph 19: Ownership of non-agricultural businesses in Rwanda



Graph 20: Percentage who receive more than half of their income from non-agricultural activities in Rwanda

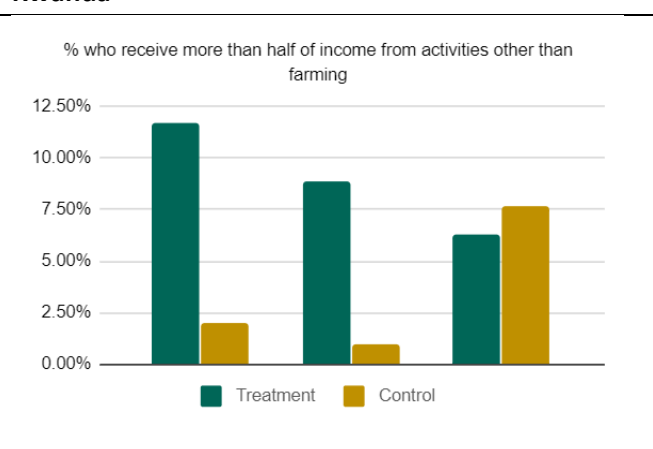


Table 4. Income - Difference in Change from Baseline for One Acre Fund vs Control Farmers				
Outcomes of Interest	Kenya		Rwanda	
	2016	2017	2016	2017
Year compared to the baseline				
Total Income in past two weeks (USD)	-6.9***	-13.62***	-1.03	-2.060
Total income in the past 2 weeks (excluding remittances - USD)	-5.1***	-11.54***	-1.33	-1.222
Non-agricultural business				
% of household who have any non-ag business	-4.6%	-13.1%***	-1.5%	-0.0387
% who receive more than half of income from activities other than farming	-30.4%**	-28.3%***	-13.7%***	-10.8%***
Average business profit per typical farmer in the past month	-5.4*	-5.58	0.0	0.103
Average business profit in the past month (only those who had a business)	-6.8		-4.2	-68.09
Total # of businesses per household	0.05	-0.17***	0.00	-0.0303
Average # of businesses created in the past year per hh	-0.06***	-0.03	0.04	-0.0223
% of households who created a non-ag business in the past year	-5.7%***	-2.25%	22.3%	0.00518
Details of self-reported income (past 2 weeks)				
Wages income	-2.6*	-5.8***	0.49***	-0.0938
Selling eggs income	0.04*	-0.06	0	0.0105*
Selling milk income	-0.1	0.03	0.0	0.126
Selling livestock income	-0.2	-0.21	-0.5	-0.434
Selling grains income	-0.6	-2.6***	0.0	0.0918
Selling vegetables income	0.1	0.13	0.0	0.00321
Remittances income	-1.8**	-2.1*	0.1	-0.139
Business profit income	-1.7*	-3***	N/A	

*** p<0.01, ** p<0.05, * p<0.1

All Other Outcomes

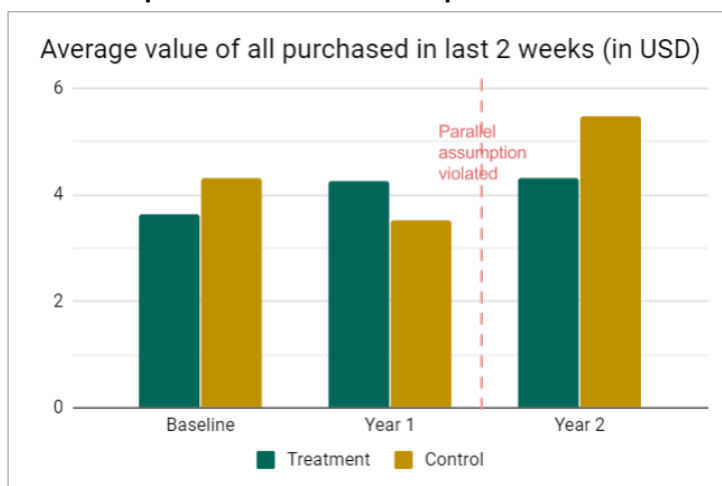
As evidenced in the sections above, due to the drought in Kenya and violation of the parallel trends assumption in Rwanda, we have seen very low impact on our primary outcome (increase in yield) and very mixed results on the immediate secondary outcomes that would then follow (hunger, assets, income). It becomes increasingly difficult to have any impact in a poor harvest year such as we saw in Year 2. Given this, in Year 2,

we see minimal or no impact on outcomes related to child education, consumption, and health, or some anomalous findings in other exploratory areas such as women’s economic empowerment.

Child Education: In Rwanda, we saw no impact on education outcomes. In Kenya, there was a decrease in the percentage of children who are attending school by 4.8%. However, baseline school attendance rates were already high at over 90% for both treatment and control, so the differences are minute. On the other hand, we also found an increase in average school costs for One Acre Fund children by \$8.60, as well as time spent on homework by 0.14 hours the previous night.

Consumption: In Rwanda, although we had noted program impact on purchases in the past 2 weeks in the first year, this impact has disappeared in the second year of the study. Although there was a steady and moderate increase in the consumption for One Acre Fund clients, there was a particularly big jump in consumption for control farmers. This might have been due to the external intervention in control sites, such as market access programs that were reported in the area but not in treatment areas. No impact on consumption has been noted in Kenya either in Year 1 or Year 2 of the study, which may have to do with the timing of the survey a full eight months after harvest and its associated impacts in Kenya (the survey was only three months after harvest in Rwanda).

Graph 21: Trends in Consumption in Rwanda



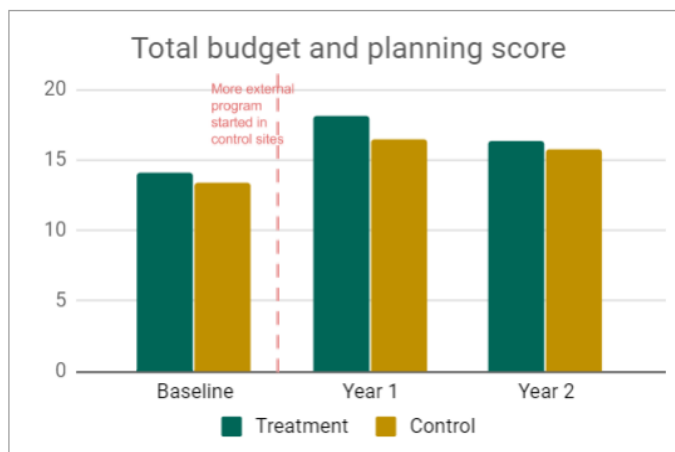
Health Access and Spending: In both Kenya and Rwanda, we saw no statistically significant difference in health outcomes between One Acre Fund and control farmers and their families. In Kenya, this is not terribly surprising, as the links between increased harvests and health spending are already more tenuous. In the event of a drought, it would be even more difficult to achieve any impact. In Rwanda, farmers reported giving high preference to buying insurance if they have extra money. However, the combination of abnormal public health issues and relatively better harvests than the previous year in the control site would have masked any impact on this indicator in Rwanda.

Child Nutrition: To measure child nutrition, we take physical weights, height, and middle upper arm circumference (MUAC) measurements of all children five years of age and below in the households covered to better understand the nutritional status of children in our sample. Due to government restrictions, we were not able to collect such measurements for children in our sample in Rwanda.

Strangely, in the first year of the study in Kenya, we saw a negative impact on malnourishment rates for children in One Acre Fund households. At that time we had considered this finding anomalous since it was highly unlikely that One Acre Fund could have made any impact on child nutritional status within just one year, we did not find corroborating increases in malnutrition for One Acre Fund children using alternative measures such as MUAC, and we had results showing decreased hunger and higher dietary diversity for children in One Acre Fund households. Keeping with this, we found no impact (positive or negative) on child nutrition status in the second year of the study in Kenya, which also supports the idea that the negative finding on malnourishment in the first year was a statistical anomaly.

Financial Literacy: We saw no impact on the total budget and planning score in Kenya. In Rwanda, the impact on total financial score in the first year was partially washed away in the second year. On closer examination, we saw that although One Acre Fund farmers did see an increase on this score, control farmers reported slightly higher scores for this indicator. Again, this is possibly a result of the external programs that were present in control but not treatment areas.

Graph 22: Total Budget and Planning Score in Rwanda



Well-Being: To assess farmer well-being, we administered a stress index as well as a happiness and satisfaction index. The stress score is based on the farmer’s perception on his/her control on their life, confidence to handle personal problems, not feeling like things are going their way, and overcoming difficulties. In Kenya, where One Acre Fund farmers saw much higher increases in harvests in 2015, as compared to One Acre Fund farmers in Rwanda, and we noted they reported less stress and more happiness than control farmers. This impact continued into the second year, with One Acre Fund farmers in Kenya continuing to report less stress than control farmers.

Women’s Empowerment: In the case of dual headed households, farmers were asked to report on who was the decision maker in the household for important decisions related to household life, crop farming, major and minor expenditures, children’s education, and food. This was done to gauge women’s participation in decision making. We also created a composite score to measure overall empowerment for women’s decision making within the household (ranging from 0 to 10).

The One Acre Fund program does not explicitly have a gender empowerment program, and we do not expect to impact gender norms, as such behaviors can take years to change. As such, we did not find any impact on the total empowerment score in Rwanda. We did, however, see a negative impact on the total empowerment

score in Kenya by 0.59 points. However, we don't detect any causal mechanisms through which the One Acre Fund program could have much impact on gender dynamics (positive or negative), so consider these findings anomalous.

Table 5. Outcomes - Difference in Change Since Baseline for One Acre Fund vs Control Farmers				
Outcomes of Interest	Kenya		Rwanda	
	2016	2017	2016	2017
Year compared to the baseline				
Education				
% of children attending school	-3.2%*	-4.8%***	6.0%	2.9%
Average hours of homework last school night	0.1	0.14**	0.12	13.0%
Average school costs (outliers winsorized at 2*std. dev)	31.7	8.6**	0.0	-2825.0
Overall Consumption Value				
Value of large purchases in the last year (in USD)	13.3	-1.3	22.35*	-12.38
Value of all purchases in last 2 weeks (in USD)	0.2	0.2	1.2**	0.562
Value of food consumed in last 2 days (in USD)	-0.2	0.2	0.1	0.355
Financial Literacy				
Total budget and planning score	0.611*	0.48	1.160***	-0.277
Health				
% of households reporting an illness in last 2 weeks	4.80%	0.88%	3.30%	-3.01%
% of those who sought treatment who saw a doctor or nurse	-5.60%	-1.50%	-2.10%	5.56%
Average health costs (outliers winsorized at 2*std. dev)	11.1	3.2	0.1	2.695*
Well Being				
Total stress score (higher score = more stress)	- 0.834***	-0.754***	0.119	0.269
Women's Empowerment				
Total women's empowerment score (0 = woman not a decision maker in any aspect, 10 = woman is the primary decision maker in all aspects)	-0.0245	-0.589**	0.194	-0.0438
Child Nutrition				
% malnourished (weight for age at < - 2 sd of WHO median)	8.6%**	-2.10%	N/A	N/A
% of children stunted (height for age at < - 2 sd of WHO median)	-2.10%	8.95%	N/A	N/A
% of children wasted (weight for height at < - 2 sd of WHO median)	-3.30%	9.70%	N/A	N/A

Recommendations for Programmatic Focus

- 1. Fortifying Agricultural Income:** Our findings from the study show that farmers prefer to re-invest agricultural profits back into farming or businesses that are offshoots from agriculture (such as selling food grains, rearing livestock, and selling produce). One Acre Fund can explore how to continue supporting farmers as they move to higher degrees of agricultural investment through participation in the One Acre Fund program. Currently, One Acre Fund already supports farmers to expand their package size incrementally as they spend longer times within the program (and therefore are able to invest more into agriculture). Since we found that the One Acre Fund program encourages farmers to deepen their roots within agriculture, it is even more important to explore all ways to help farmers maximize their agricultural profit, such as better market access programs, and income avenues that complement agriculture, such as livestock rearing. We also know, as evidenced by the 2016 drought,

that smallholding agriculture is inherently risky and reliant on the vagaries of the weather. Given the realities of climate change, it is more critical than ever to explore programs that insulate farmers (to the greatest possible extent) from such agricultural shocks by promoting drought-resistant crops, or even irrigation. One Acre Fund already has made some progress in this regard. For example, One Acre Fund farmers are encouraged to plant using lime, which helps keep soil acidity levels in control. In 2018, 26% of total clients in Kenya adopted lime, which will be a big contributor to long-term soil health. Currently, One Acre Fund in Rwanda is also trialing a poultry program as another income source and hoping to roll out in the entire program regions soon.

2. **Crop Insurance:** Building on the recommendation in Point 1, it is also important to create a safety net for farmers (both new and those that are now expanding their agricultural investments). One Acre Fund already provides crop insurance for clients, which can go a long way in insulating them from agricultural shocks. Insurance for smallholding agriculture is tricky and also difficult to implement perfectly. For example, the crop insurance provided for clients in Rwanda may not have provided the expected buffer it was supposed to. In the 2017A season, the payout to each farmer was 0.8 dollar and delivered in the form of discount for the next season. Although this may have helped cash-strapped farmers to be able to buy inputs for the next season, it would be worth exploring ways to enhance the current crop insurance provided to One Acre Fund clients.
3. **Productive and Tradable Assets:** Productive and tradable assets (such as livestock) can be very useful in insulating farmers from income shocks and building their resilience for difficult periods. Apart from providing an extra income boost or nutritious food for the family (eggs, milk, etc.), livestock can also be sold for extra money when liquidity is low for immediate basic needs. We have found that livestock gains made by One Acre Fund farmers in the good agricultural year were particularly helpful in tiding them through the difficult drought period in Kenya. Our findings of over two years of the study validate that farmers already prioritize investing in livestock after seeing increases in income, and these investments have been useful in providing them with much needed liquidity when required. We have already piloted several livestock-related programs. However, adoption for these products by farmers has historically been low. They may be more interested in buying livestock, but not driven to invest in higher-quality livestock after just one year of increased harvests, perhaps due to several competing needs that also have to be addressed, such as food, school fees, etc. In that case, it would be important to understand what constraints they face even after their income increases and make efforts to lower these barriers.
4. **Pest Control:** Farmers in East Africa have suffered recently suffered outbreaks of fall armyworm, an invasive pest that can devastate maize yields when left unchecked. Through our qualitative study in Rwanda, One Acre Fund farmers testified that they had been expecting good yields before pests damaged their crop severely. Farmers requested to include pesticide in our product offerings. In fact, internal “yield driver” analysis in 2017 also revealed that pesticide usage was an important contributor to yield increases. Work is already underway in this regard. As One Acre Fund gains more confidence in the efficacy and safety of pesticides through rigorous trials, we are planning to expand the regions where it is offered in the upcoming seasons. Any pesticide offerings would be coupled with training and advice on application materials, to ensure that these products are used safely and in proper amounts so as not to affect the external environment.

ANNEXURE

ANNEX A: Background and Program Description

Farmers make up 70% of the world's poor. Yet most live in remote areas and do not have access to basic agricultural tools and trainings. As a result, they struggle to grow enough to feed their families, and face an annual hunger season, a period of meal skipping and substitution that often affects children the hardest. Year after year, the farmers find themselves trapped in a cycle of low yields and continued poverty.

Specifically, many rural smallholders lack the access to improved farming technology due to cash constraints, geographic isolation, and lack of training programs. Founded in Kenya in 2006 and Rwanda in 2007, One Acre Fund provides a bundle of services to address these barriers to improved yields. Farmers are provided seed and fertilizer on credit and can pay back on a flexible repayment schedule throughout the year or season. Farmers form groups that are jointly responsible for repayment. They are offered regular training, which covers topics such as optimal planting practices, fertilizer application, pest management, and safe storage of harvests. Farmers are also provided crop insurance and have the option to purchase other products with proven income and/or quality of life impacts, such as solar lamps (our most popular add-on product) and cook stoves.

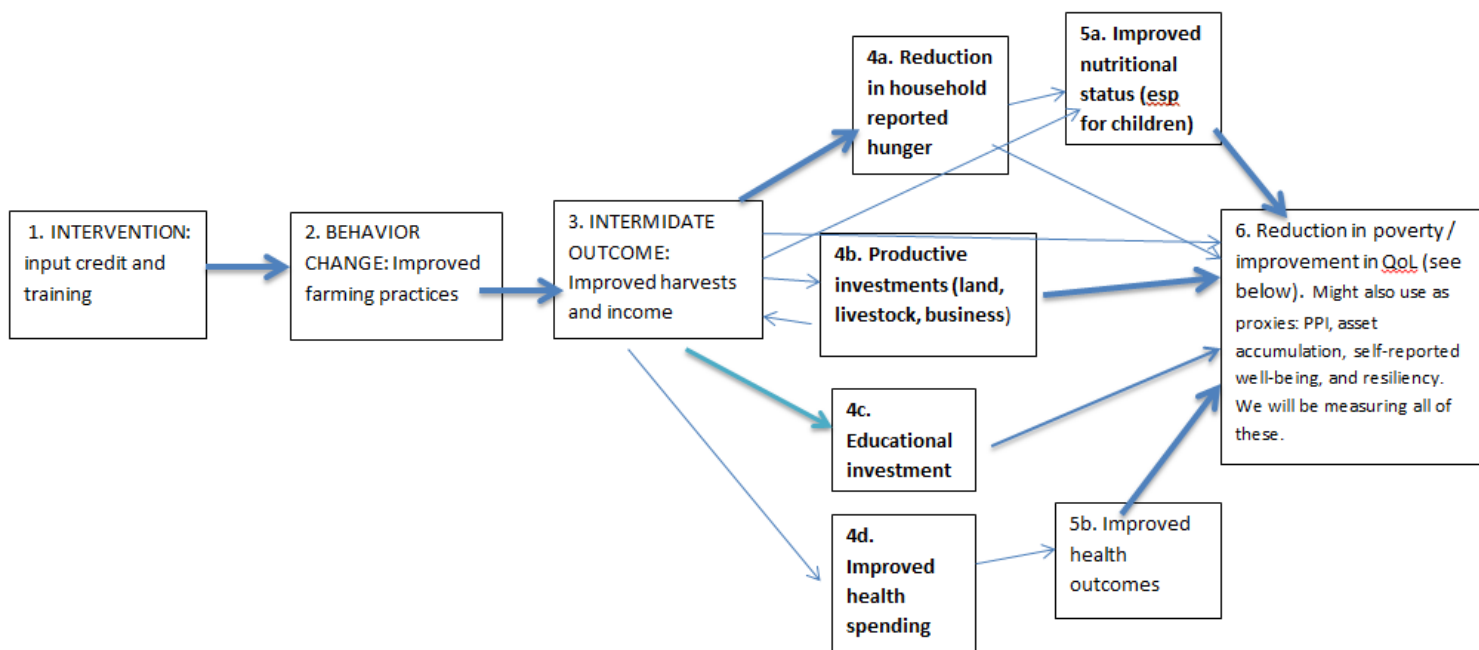
The core program of One Acre Fund in Kenya is spread over the Western, Nyanza, Central, and Rift Valley regions and across different agro-economic conditions. Altitude can range between 1,227 and 1,914 meters and annual rainfall can range between 1,028 and 2,112 millimeters. Farmers enrolled in Kenya usually plant crops on 1.3 acres of land out of which 0.6 acres are allotted on average to program-specific inputs. The Kenya program enrolls farmers in one season each year and includes a package of seed, fertilizer, and other products with training. Neighboring farmers have relatively low fertilizer use and access to training. Therefore, we expect (and have seen historically) program effects to be larger in Kenya, relative to other country programs.

The core program of One Acre Fund in Rwanda is similar to Kenya, but farmers in Rwanda have different agricultural environments and available resources. The core program is spread over across most of the country's agro-economic conditions except the Northwest region. In Rwanda, altitude can range between 800 and 4,480 meters, and annual rainfall can range between 378 and 2,564 millimeters according to the region. Farmers enrolled in Rwanda usually plant their crops on one acre of land, out of which 0.4 acres are allotted on average to program-specific inputs. The Rwanda program enrolls farmers two seasons each year and includes a package of fertilizer and seeds with training. Unlike Kenya, neighboring farmers have decent access to fertilizer through agro-dealers, and One Acre Fund actually helps agro-dealers supply quality fertilizer and timely deliver to any farmer regardless of their program enrollment. One Acre Fund also has partnered with the government to improve extension services in the country, which intends to reach every single village. One Acre Fund has provided training tools and checklists to "farmer promoters," who in turn pass on this knowledge to farmers in their home areas. Given agricultural support such as access to fertilizer and training among control farmers, we do not expect the program impacts of our core program (excluding government-partnership programs) to be quite as large in Rwanda.

One Acre Fund's program aims to bring changes toward the ultimate goal of a reduction of poverty and improvements in quality of life for our farmer clients. Below is One Acre Fund's theory of change, focused on

our core target population of farmers and their families. It moves from our direct program components to → behavior change to → increases in harvests. We have measured our impact on all of these fronts, keeping careful track of our program components through Key Performance Indicators of farmers’ behavior change through planting compliance surveys and of direct outcomes through our annual impact assessments.

Less known is our theorized improvements in other aspects of our farmers’ lives, which are often interrelated, and which we hope lead ultimately to a reduction in poverty and improvements in quality of life.



The bolder arrows represent more established links

- From 1-2: We regularly assess improved farming practices in our planting compliance survey in each country and confirm a high compliance with our practices. In 2014 and 2015, we took this one step further and a) assessed spillover of our practices to neighboring farmers, and b) looked at the degree to which ex-clients are retaining our practices. The two studies show that program spillover is happening to control farmers, and ex-clients demonstrated higher compliance with better agricultural practice and better maize yields than farmers who never participated in the program.
- From 2-3: We regularly assess improvements in yields and profits as part of our annual impact assessments. Comparing One Acre Fund and non-One Acre Fund farmers, we have regularly measured an improvement in yields and profits from 10% to 100%, but typically about 30-50% per farmer.
- From 3-4a: We have done some initial assessments of harvest yields on hunger outcomes (maize remaining in store and FANTA scales) and have detected a strong statistically significant relationship at each assessment (effect size of 0.33 in grain stored and FANTA effect size of 0.25-0.5.)
- From 3-4b: We know less about the magnitude and diversity of other investments (business, farm, livestock, etc.).
- From 3-4c: We have one study (CEGA 2012) showing improvements in educational expenditures, however this could be explored further.

- From 3-4d: We have little internal data on any changes in health spending or resilience to health shocks.
- From 3-5a: There's a paucity of literature on the links between agricultural interventions and nutrition alleviation.
- From 4a-5a: Reduction in hunger should logically lead to improvements in malnutrition. However, this is likely mitigated by distribution of resources within the household (e.g. children are most susceptible to malnutrition, but when household hunger improves, this might not improve their outcomes if they do not receive a significant piece of the pie), as well as the type of food eaten (e.g. if certain vitamins are lacking, alleviating hunger will not improve some nutritional outcomes).
- From 4b-5b: Presumably increased health spending should lead to improved health outcomes. However, this will vary greatly depending on the quality of care in each environment (there's a rich body of literature we can investigate more).
- From 4a-6: Hunger alleviation. By causing poor health, small body size, low levels of energy, and reductions in mental functioning, hunger can lead to even greater poverty by reducing people's ability to work and learn, thus leading to even greater hunger (see Victoria et al. [2008](#)).
- From 5a-6: Ameliorating malnutrition. Stunted children suffer IQ loss, a higher likelihood of entering school and not completing basic education, as well as later onset of nutrition-related chronic diseases (diabetes, hypertension, heart disease among others) that lead to early death, and diminished quality of life without needed health care services because of income constraints (see [Hunt 2005](#)).
- From 4b-6: Productive investments (can be divided into agriculture, livestock, and small business). See this [working paper](#) on livestock investments and [Shchneider and Gugerty 2011](#) on agricultural investments. There is a wide breadth of research in the importance of small business for poverty alleviation.
- From 4c-6: There is a large body of evidence that more access to education leads to long-term poverty reduction (see [Dercon & Shapiro 2007](#)).
- From 5b-6: Better health outcomes are strongly linked with better ability to escape poverty (see [Dercon & Shapiro 2007](#). Also the WHO says: "Illness can reduce household savings, lower learning ability, reduce productivity, and lead to a diminished quality of life, thereby perpetuating or even increasing poverty."
- From 3-6: Agricultural productivity to poverty alleviation. There are established linkages between increases in agricultural productivity and poverty reduction. The evidence suggests that there are multiple pathways through which increases in agricultural productivity can reduce poverty, including real income changes, employment generation, rural non-farm multiplier effects, and food prices effects (see [Shchneider and Gugerty 2011](#). Also see [IFPRI's analysis](#) on halving African poverty by increasing investments in agriculture at the macro level).

Annex B. Site Selection

The overall evaluation approach we are taking is a difference-in-differences design with propensity score matching, where geography is used to narrow the pool of potential treatment and comparison farmers. We select control farmers from just beyond a relatively arbitrary boundary, beyond which we will not offer our program, and treatment farmers from the other side of that boundary.

In selecting sites for our study, we considered the following criteria:

- Relatively new areas of our program (so we can catch farmers on the bottom of the curve of any potential upward trajectory).
- Not an “outlier” area in terms of agro-ecological conditions or farmers demographics, so that it is fairly typical of program performance.
- Not an area in which we are running too many program trials, so that the program intervention is fairly typical of our program overall.
- Cluster of sites to one side of an area we are willing to hold off expansion.
- No major known problem with staff performance in the area.
- Border area should not be a stream, road or meaningful administrative boundary but as arbitrary as possible.

ANNEX C: Potential Risks and Mitigation

In the study design, we had anticipated the likelihood of program attrition (both from the study as well as the program) over the four-year study duration. We also considered the possibility of contamination (controls migrating into the program) taking place. We have noticed some attrition and spillover after one year of the study. This does not have any bearing on the analysis for the first two years of the study. However, this will factor into our analysis in the third round of data collection. The details and implications are listed below.

Contaminated controls

Kenya: After the first year, 116 control farmers (out of a total of 1,200) crossed over the program border to enroll in the One Acre Fund program. While these “contaminated” control farmers would not have seen the benefits of the One Acre Fund program during the time of data collection of the second round, they will be excluded from the analysis from the third round onwards. One Acre Fund’s Monitoring & Evaluation team is working very closely with the Kenya Field team to ensure that control farmers are not enrolled into the program in the remaining years of the study. As an additional analysis, after all rounds of data collection, we will be looking at these “contaminated” control farmers to better understand possible dosage effects of each year of One Acre Fund program participation.

Rwanda: In order to make sure that we do not have much contamination, the program team in Rwanda does not provide incentives to any group leader who recruits farmers from the program sites. This policy has worked well until now, minimizing the number of control farmers who enrolled to only five in the first year and 14 in the second year.

Study Attrition

Kenya: The enumerators of the study tried to reach out to each farmer within the study. At least three attempts were made to visit every farmer and undertake the survey. Eventually, 379 farmers could not be reached for the second or third (or both) rounds of data collection. This is because these farmers had moved away, died, or refused to take the survey.

Rwanda: Despite persistent search by the enumerators, we could not conduct the survey with 99 farmers in Year 1 and 87 in Year 2 who initially participated in the baseline study. They moved to another area or had died.

Program Attrition

Kenya: Around 419 One Acre Fund farmers left the program after two years of program participation. This is roughly what we had expected in terms of program attrition. We do not expect all farmers to continue with the program for the entire duration of this study. As an additional analysis, we will be looking at these farmers to better understand possible dosage effect of each year of One Acre Fund program participation after all rounds of data collection.

Rwanda: The program attrition in Rwanda is relatively larger than Kenya. A large number of One Acre Fund farmers who participated in the first round study (the larger A season) left the program in the B season. We had about 78% of the A season farmers not rejoin in the B season in 2016. It is possible that poor germination of beans in the first season discouraged farmers from rejoining. Some of farmers returned to the program in 2017, but we still have 42% of original participants in the program who did not rejoin in 2017. Traditionally, in Rwanda a large proportion of A season clients do not rejoin B season when beans are the main crop, to which farmers do not apply fertilizer. As the baseline was carried out in the A season and the Year 2 study was carried out in B season, some attrition was expected. Combined with the bean germination issue in the baseline year, its seasonal character contributed to much larger attrition in Rwanda compared to Kenya. Due to the huge attrition in Year 1 in Rwanda, unlike Kenya, we included farmers who didn't rejoin the program in Year 1 but did in Year 2 in our analysis.

ANNEX D. Analysis Strategy – Difference-in-Difference and Propensity Score Matching

Difference-in-Difference: Despite the careful site selection and sample strategy in order to reduce bias, the balance tests conducted at the baseline show some differences between control and program farmers. To overcome this, we have used difference-in-difference (DD) and propensity score matching (PSM) to eliminate bias. This would help control the differences and enable us to estimate more accurate impact. DD estimation helps us to control factors (both observed and unobserved) that do not change over time and might influence outcomes. These factors can be age, education level, and risk-aversion character of a farmer. PSM allows us to refine our control farmers based on their characteristics to make them as comparable to One Acre Fund farmers as possible.

DD might be problematic if only one group has been affected by an event (violation of parallel trends assumption), which is what we saw in Rwanda in Year 2. PSM heavily depends on its model. Depending on factors included in its model to compute propensity score, the model can be unbalanced between two groups and sensitive to factors that were not included in the model but also influence outcome variables. We thoroughly checked models' balance and sensitivity throughout our analysis and are confident that our models are well constructed.

Propensity Score Matching: We have also used Propensity Score Matching as a control refinement technique to smooth out differences between treatment and control farmers. We have used nearest neighbor matching (up to two matches) for the matching model. We have found the models to be well balanced with adequate common support area.

Treatment of Outliers: Self-reported data on expenditures and income are notoriously difficult to collect.³ Precise estimates can be difficult for respondents to recall, and there are possible biases at play. Respondents might have an incentive to under-report income, for example, with the assumption that this might qualify them for a social program, or to over-report due to shame about how little they have. We have attempted to minimize these biases as much as possible by reassuring respondents about the confidentiality of their response and also by assuring them that nothing they say will qualify or disqualify them for a program benefit. Furthermore, where possible, some of the questions related to recall have been kept to a time period of two weeks to obtain more accurate information. In addition, for income and expenditure data, which had long tails at either end of their data distribution, we have **winsorized outliers to two times the average standard deviation** in order to better identify real differences among our study groups⁴. For such variables with high variance, the outliers were identified as those that were more than two times the standard deviation of the variable. The results for such data have been reported without the outliers. Information on results with the outliers can be shared on request.

Multiple Hypothesis Issues: We will be testing numerous hypotheses to understand the impact of the One Acre Fund program on all aspects of the lives of farmers and their families. Given the sheer number of variables being tested, it is possible that some outcomes are statistically significant by chance. This is especially the case when we test changes in almost 100 individual assets and consumption patterns. To overcome this, we will look at index variables, where relevant, that represent the sum of total asset type and consumption patterns for different time periods.

³ See “Assessing the Reliability of Household Expenditure Data: Results of the World Health Survey” World Health Organization. Discussion Paper #5, 2007

⁴ At the baseline, we had used the strategy of dropping outliers. However, we lost a lot of data points using this strategy. We prefer the method of winsorizing outliers instead, which replaces the outliers with the value at the outlier cut-off point (e.g. + 2 times the standard deviation, but does not exclude the data points from the analysis).