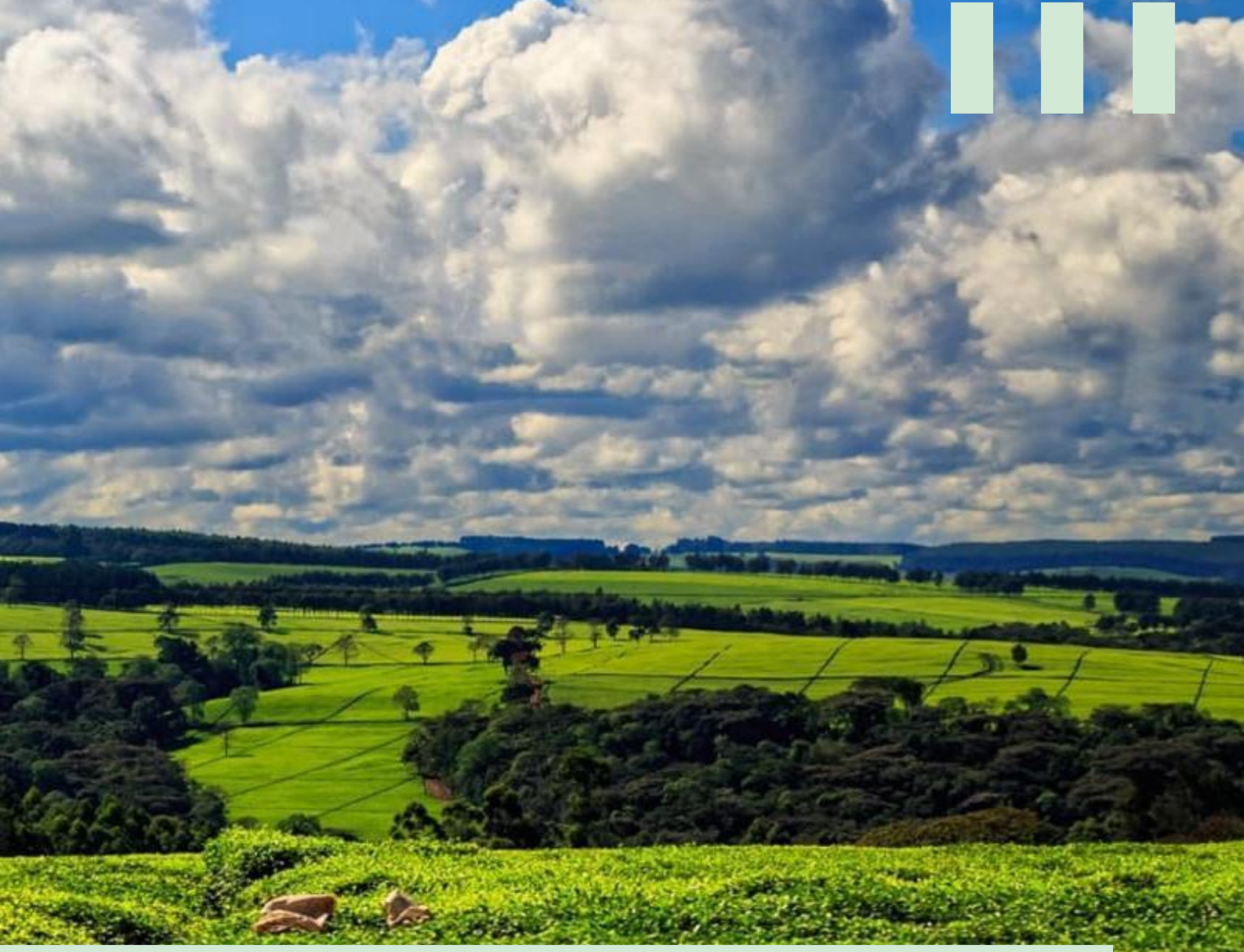

One Acre Fund Tree Program: Endline Report

Endline Findings Report

September 2021

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One Acre Fund Tree Program: Endline Report

September 2021

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3. List of abbreviations

1AF	One Acre Fund
BL	Baseline
FGD	Focus Group Discussion
FO	Field Officer
JiT	Just in Time
KII	Key Informant Interview
KES	Kenyan Shillings
LATE	Local Average Treatment Effect
NPV	Net Present Value
(C)RCT	(Cluster) Randomized Control Trial
TLUs	Tropical Livestock Units
WTP	Willingness to Pay

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1 Introduction

One Acre Fund (1AF) has been supporting smallholder farmers in Kenya through the provision of agricultural training and financing since 2006. The financing component involves providing farmers with farm inputs on credit at the time of planting, who then make repayments to 1AF in installments over the season. The inputs primarily constitute a core package that contains improved maize seeds, bean seeds, fertilizer and a range of add-on products such as solar lights, vegetable seeds, improved crop storage bags, cook stoves, and sanitary pads.

In 2010, 1AF introduced a Tree Program to their core loan package with the aim of increasing the client farmers' tree assets as a source of extra income from their sale. The Tree Program contains grevillea seeds, planting fertilizer, large planting the seeds, smaller planting bags for raising individual seedlings once they are big enough, and a set of trainings specifically on tree planting and maintenance.

Laterite was contracted by 1AF in 2018 to undertake a randomized control trial (RCT) to evaluate the impact of the Tree Program in the Kericho and Uasin Gishu counties[1] of Kenya, where 1AF expanded their program in the 2019 long rains season. The expansion of 1AF operations into new areas of Kenya gave a unique opportunity for an impact evaluation that is not compromised to pre-exposure to the program. Laterite was responsible for all stages of the impact evaluation, from design through data collection, data cleaning, analysis and reporting.

Baseline and midline data collection took place between February and March in 2019 and 2020, respectively. At baseline, Laterite conducted quantitative interviews with 1,852 farmers in both treatment and control groups as well as 10 Focus Group Discussions (FGDs) with 8 to 10 farmers each in the study areas. At midline, Laterite attempted to re-visit all the farmers from the baseline quantitative sample. In total, 1,730 farmers out of 1,852 farmers interviewed at baseline responded to the midline survey, representing a 93% response rate. A mop-up survey to interview farmers who were temporarily unavailable as well as a planned tree trader study did not take place due to the outbreak of the COVID-19 pandemic and the restrictions associated with it.

The scope of the endline stage changed from the originally planned quantitative and qualitative components due to the ongoing COVID-19 pandemic. This stage was planned to include quantitative interviews with all farmers interviewed at midline and 10 FGDs with 8 to 10 participants. Instead, Laterite conducted phone surveys with 293 farmers (17% of the midline sample), 10 FGDs with an average of four participants, and 22 Key Informant Interviews (KIIs) with 1AF's field staff. Additionally, we completed a tree trader survey scheduled for midline with 277 tree traders.

[1] For the purposes of the 1AF program, the expansion area comprises Kipkelion- and Kabiyet districts. Kenya's administrative divisions were adjusted under the 2010 constitution.

This report provides the endline evaluation findings, which are organized to align with the research objectives and hypotheses set at the beginning of the evaluation. The endline research questions focus on the uses and valuation of tree assets to better understand and contextualize the impact of One Acre Fund's Tree Program. We note that there are limitations to the internal and external validity of this study.

Among the risks to the internal validity of the endline findings are the reduced scope and sample of our endline study. While the scope of the endline survey permits to answer questions about tree usages and farmer' attitudes towards trees and the 1AF Tree Program, we did not capture detailed data around the costs of tree planting and maintenance. Further, even though the endline sample was drawn randomly and it is representative of the midline sample, it only contains about 17% of the midline observations. Conclusions drawn from the endline sample have therefore been drawn very cautiously and as estimations only. We cannot differentiate between the treatment and control groups at endline due to lack of statistical power and extrapolations to the larger sample also need to be taken carefully.

We also encounter limitations to the external validity of our findings, as previously outlined in the midline report. First, 1AF finds in their internal reports that the 2019 expansion areas are not fully similar to other program areas. The study area had a higher number of pre-existing timber trees compared to other districts, which might affect our ability to assess an incremental impact on the number of timber trees planted. Second, in 2019 the input delivery was delayed due to supply issues, which led to alterations to the tree training schedule and some trainings related to tree planting might not have been delivered at all. Third, the program was affected by seasonal effects. In 2019, the long rains came late and around a quarter of 1AF farmers had to replace their field with new seed because of this. Fourth, the 1AF Tree Program has changed since this study began. 1AF is now distributing eucalyptus and cypress trees in areas that are safe to plant and the organization is trialing distributing seedlings rather than seeds.

The endline survey brings additional limitations to the external validity of this study. Most importantly, the COVID-19 pandemic has created exogenous shocks that might affect market data related to the prices and willingness to pay for timber trees of 1AF's farmers. These limitations constrain our ability to generalize the findings of this report to the overall Tree Program.

2 Summary of findings at midline

Over the course of this three-year study, we aimed to look at the effect of the 1AF Tree Program on the uptake of tree planting activities, the survival rates of planted trees, the financial value of tree assets, and the perceptions and attitudes of farmers towards tree planting.

We summarize findings from the baseline and midline surveys following the key research questions of this study:

1. **What are the socio-economic determinants of (grevillea) tree-planting?**

   At baseline, the county of residence was the main source of heterogeneity in tree-planting. While a very high proportion of 1AF farmers (97%) grew trees at baseline, there were significant differences in the proportion of farmers that grew various types of trees by county. Timber trees were grown by more farmers (96%) in Uasin Gishu compared to Kericho (92%), fruit trees were more common in Kericho with 77% of farmers having at least one fruit tree on their farm compared to 67% in Uasin Gishu. Indigenous and exotic trees outside the timber- and fruit categories were also more common in Uasin Gishu than in Kericho. The differences for these tree categories were significant at the 1% level, even when including demographic and socio-economic variables in the regression models.

   Farmers in Kericho were more likely to grow grevillea trees than farmers in Uasin Gishu at baseline. Over half (56%) of farmers in Kericho grew grevillea trees at this point compared to a third (35%) of farmers in Uasin Gishu. In contrast, cypress was predominant in Uasin Gishu with 91% of the farmers growing this tree at baseline, compared to 69% of farmers in Kericho. Both these differences are significant at the 1% level and robust to model specifications. There was no significant difference in the share of 1AF farmers that grew eucalyptus, pine, and other timber trees at baseline.

   Education was also a strong predictor of tree planting at baseline. Farmers that completed primary education are significantly more likely to grow trees in general, and timber trees specifically. The relationship is statistically significant for each type of timber tree, except pine, at baseline.

   Finally, the gender of the household head[2] has a strong correlation with trees grown at baseline, whereby female headed households were less likely to grow trees at baseline. Female headed households were less likely to grow trees in general, and timber trees, including grevillea and eucalyptus specifically.

[2] Note that the household head and the One Acre Fund farmer might differ. The household head is the person identified by the respondent to be in charge of household decision-making, while the 1AF farmer is the person whose name appears on the 1AF contract.

2. **Does a farmer's knowledge of best practices for tree planting and tree maintenance improve as a result of the tree program?**

Findings related to tree-planting knowledge at midline were based on incomplete compliance and participation in training. An estimated 92.2% of the treatment farmers received the tree kit, while only 61.3% received the tree kit and attended the accompanying training (the latter are "full compliers"). There was also non-compliance in the control group: the study found that 3.4% control arm farmers received the grevillea tree kit and an estimated 20.8% attended the training on tree planting. The most common reason for not attending the tree training was not knowing about it (63% of farmers in the treatment group that did not attend the tree training did not know about it).

The findings we report from the midline study are based on an intention-to-treat effect (ITT). The high level of non-in both the treatment and control groups implies that this estimate will be an underestimation of the actual treatment effect on the treated.

We find an intention-to-treat effect for the knowledge on using the correct soil for planting tree seeds. There was a 13.2 percentage point increase in the share of farmers that knew that they should gather soil from close to a healthy tree, use topsoil only, use a mix of topsoil and sand, or specifically not using clay soil at midline in the treatment group compared to the control group. In aggregate, the treatment also has a positive and statistically significant effect on the number of knowledge questions that the farmers answer correctly. There was no significant change in the knowledge of other best practices asked at baseline. These questions were about the time farmers should wait for a seed to germinate (two months or more), how often they should water the seeds if it does not rain (at least once a day), what they can do to maximize germination rates, and correct pruning (25% of the branches or less). The lack of effect these other practices might be explained by the low attendance rate to the tree trainings. These trainings might not have been offered at all in some places according to the One Acre Fund.

3. **To what extent do grevillea survival rates among treatment farmers correlate with the level of knowledge of best practices for tree-planting outlined in the training sessions?**

At the time of the midline survey, 68.7% of the treatment farmers had planted grevillea seeds from the tree kit in tree bags. Only about a quarter (25%) of treatment farmers went on to plant these trees in the ground. We find relatively high survival rates for tree seedlings that were planted on the ground for the treatment farmers. Around two-thirds of the seeds planted from the tree kits had survived at the time of the midline data collection.

We did not find a statistically significant correlation between attending the tree training and the survival rate for grevillea trees from the tree kit. We also did not find any other demographic and socio-economic variable from baseline to be correlated to tree survival rates at midline.

We did however find a positive and statistically significant (at the 1%) level association between knowledge on tree planting best practices and survival rates for the treatment group. Farmers that responded correctly to more knowledge questions were more likely to have surviving grevillea trees on their plots. On average and holding everything else equal, farmers that answered one additional knowledge question correctly had a 3-percentage point higher grevillea survival rate at midline.

4. **Do treatment farmers have additional trees after the *two* years compared to control farmers; how many additional trees do they have on average?**

We find that after *one year* of the 1AF Tree Program, farmers in the treatment group had on average 7 more grevillea trees and were 15.6 percentage points more likely to have planted grevillea trees compared to control group farmers. These results are statistically significant and robust to different model specifications. We find that the program effects are higher for farmers that fully complied with the program (received the tree kit and attended the tree planting training sessions) and that the effect of the treatment was higher overall for male farmers and those residing in Uasin Gishu.

We find that there was no overall treatment effect on the number of planted timber, fruit, or other trees in the past 12 months. While the number of grevillea trees planted increased significantly, the cumulative effect on the total number of timber trees was not significant We note that the effect of the treatment on whether the farmers planted timber trees and on the number of timber trees planted in the past 12 months is diminished by the fact that a higher share of farmers across both treatment arms planted timber trees at midline compared to baseline. This is especially noticeable in the share of farmer planting cypress trees and on the number of cypress trees planted

Additionally, we find a positive and statistically significant treatment effect on the number of grevillea trees as a percentage of timber trees planted in the past 12 months. This effect is also observed in the number of grevillea trees planted as a percentage of the total trees planted in the 12 months preceding the midline.

5. **Does planting trees one year preclude planting trees in subsequent years? Does receiving a tree-kit and training in 2019 correlate positively or negatively with tree planting in 2020?**

Having planted trees in 2019 is positively and significantly (at the 1% level) correlated with planting trees in 2020. While planting rates were high at baseline and midline with more than half of the farmers having planted trees at both points, there was a 19-percentage point difference at midline in the planting rates for farmers that had planted at baseline (78% planted at midline) compared to farmers that had not planted at baseline (59% planted at midline). This correlation remains significant after controlling for demographic socio-economic characteristics and

after controlling for the treatment status of the farmer. There is also a positive correlation between tree planting at midline and the household size, education level, age, and whether the 1AF farmer is male and lives in Uasin Gishu.

We find an overall positive, but not statistically significant, treatment effect on whether the farmers planted any timber, fruit, or any trees in the past 12 months and on the number of trees from these categories planted. The results point towards the possibility of these effects accumulating when we look at the total number of trees planted in the past 12 months, where we see a large (~14 trees) effect that is statistically significant at the 10% level. However, we do not have enough statistical power to confirm this hypothesis and the positive coefficients on all effects could be due to random noise.

3 Endline research questions

This report aims to build on the midline study to answer the following research questions:

1. **Uptake and survival:** What is the current and future potential financial value of the additional trees planted as a result of the 1AF tree program?
2. **Cost-Benefit:** What is the overall value to the treatment farmer per tree planted considering opportunity costs regarding land-use, time-use and cash-use? Is there a net change (increase or decrease) in the value of total tradable assets, combining trees and livestock, for the treatment farmers over the course of *one year* compared to control farmers?
3. **Attitudes:** Is there a change in farmers' perceptions and attitudes towards tree planting activities and farmers' understanding of best practices around tree-planting that can be attributed to the 1AF Tree Program?
4. **Tree uses:** What uses do farmers in our study area have for trees grown on their land? What are the main differences between the different tree species? To what extent do farmers use trees for fuel wood, construction, etc. and how are these uses quantified?
5. **Demand and pricing:** What is the demand and supply for grevillea and other timber trees? What is the farmers' willingness to pay for these trees?

4 Study Methodology

4.1 Evaluation Design and Sample

The methodology for the evaluation of the One Acre Fund Tree Program uses a dual approach comprising a rigorous experimental design and a supporting non-experimental design. The experimental design is based on quantitative interviews with 1AF farmers, while the non-experimental design comprises quantitative interviews with tree traders and qualitative interviews with farmers and 1AF field staff.

4.1.1 Experimental Design

The experimental research design is based on a cluster-randomized controlled trial (RCT) with the objective of measuring the impact of 1AF's Tree Program. The unit of randomization is the training group that a farmer is assigned to, and the unit of measurement is individual farmers.

The sampling frame includes all 1AF farmers in the new expansion sites, where 1AF started operating in 2019. At baseline, 226 training groups in 37 1AF training sites were assigned to the treatment and control arms and 1,852 farmers from these groups were sampled and interviewed. During the midline stage, Laterite attempted to re-visit all the farmers from the baseline sample. In total, 1,730 farmers out of 1,852 farmers interviewed at baseline responded to the midline survey, representing a 93% response rate. A mop-up survey to interview farmers who were temporarily unavailable did not take place due to the outbreak of the COVID-19 pandemic and the restrictions associated with it.

At endline, it was not possible to conduct a full face-to-face survey due to the ongoing COVID-19 pandemic and a phone survey with a sub-sample of the farmers was conducted instead. The phone surveys were conducted with 17% of the midline sample and had the objective of understanding the uses farmers have for timber trees planted on their land, as well as the valuation that they give trees for different use cases. In this report, we analyze the endline data directly and also extrapolate estimates from this data to use with the baseline and midline data.

4.1.2 Non-Experimental Design

The non-experimental design has the objective of contextualizing and nuancing the quantitative data. Through the qualitative component, we capture information that supports the answers to most research questions and provide useful information on the implementation of the 1AF Tree Program. The quantitative section helps us capture the demand for trees, which is required for the full examination of the research questions.

The non-experimental research design included Focus Group Discussions (FGDs), Key Informant Interviews (KIIs), and a tree trader survey. At baseline, we conducted 10 FGDs with 8 to 10 farmers each in the study areas. At endline, we conducted 11 FGDs with five to six participants each and 23 KIIs with Field Officers (FOs), Marketing Officers, and Tree Nursery Managers. Additionally, we conducted both phone and face-to-face surveys with 293 tree traders, using a snowballing sample approach.

4.2 1AF Intervention

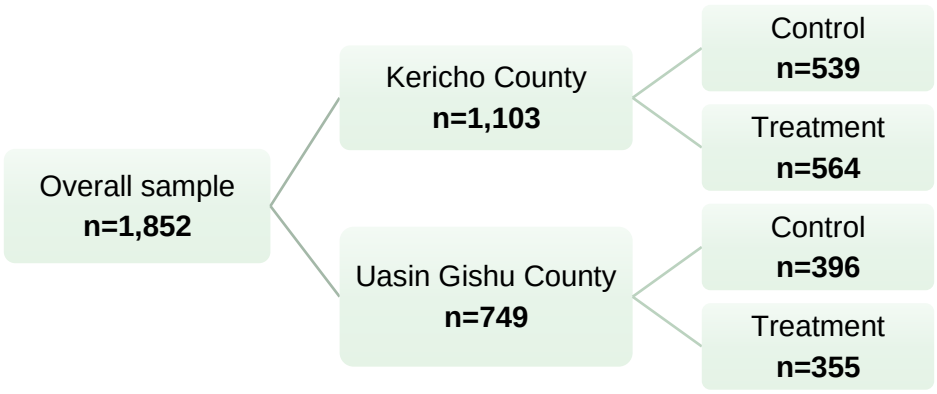
Farmers in the treatment training groups were scheduled to receive the "Tree Program". This consists of tree kits, and tree training as part of their regular base package of inputs (improved seeds and fertilizer for maize and beans plus any add-on products) for the 2019 long rains season. Control training groups were scheduled to receive a base package that did not include the tree kits and tree-specific training.

The underlying assumption for this evaluation is that treatment and control farmers differ from each other only by chance and that differences in outcomes of interest are explained by the treatment. Randomization was successful at baseline, with balanced treatment and control groups in terms of demographic and socio-economic characteristics.

4.3 Sample Size

A sample of 1,852 farmers (Figure 1) was determined to be sufficient for the research purposes of this study. At baseline, we estimated power calculations using a set of variables around tree planting, including the share of farmers that had planted timber trees in the past 12 months, the share of farmers with any grevillea trees and the number of total-, timber, grevillea, and eucalyptus trees planted on the farm. The sample size allows us to detect at least a 22% change in the number of grevillea trees a farmer (equivalent to approximately 3 trees) has and an 8% change in the share of farmers growing grevillea between the treatment and control groups at 5% significance level, 80% power, a group ratio of 1:1 and adjusting for 10% attrition rate and 10% non-compliance.

Figure 1: Baseline sample allocation by county and treatment status



At midline, the overall attrition rate was 7% and the non-compliance rate was 4%[3], with slightly more attrition in the control group and more non-compliance in the treatment group. This falls within the attrition and non-compliance margin accounted for in the power calculations and while we cannot conclude with confidence that consented and non-consented households at midline are not systematically different, joint significance tests point in this direction.

4.3.1 Endline Sample

At endline, a sub-sample of 17% of the midline sample was selected for a follow-up interview. A total of 293 farmers, divided between treatment and control, were interviewed at

[3] 1% of the control farmers received the tree kit through the Just in Time (JiT) program.

this stage. Because of the small sample, we have low statistical power for any statistical analysis conducted with the endline data directly and use this data mostly in a descriptive manner. For answers related to the cost-benefit of the program we extrapolate from this sub-sample to the entire midline sample.

The endline sample is based on a two-stage clustered random sampling method, stratified and clustered at the training group level. We used the farmers interviewed at midline as the sampling frame and removed training groups with less than 6 observations from the sampling frame to ensure sufficient observations within each cluster. In the first stage, we randomly selected 120 training groups and in the second stage we randomly selected 6 farmers from each sampled group. We attempted to interview at least two farmers per training group at endline.

All endline analysis is weighted using inverse probability weights. These weights were determined by taking the inverse probability of a farmer being interviewed within each training group and each training group being sampled from the midline data. We take these sampling weights into account whenever we extrapolate endline data to the baseline and midline samples.

We find no systematic difference between the midline and endline samples conducting a joint significance test using key outcome and demographic variables collected at midline. While the male and more educated participants are significantly over-represented in the endline sample (Table 1), there is no overall joint significant correlation between key baseline characteristics and allocation to the endline sample[4].

Therefore, we conclude that while the endline sample is small, it is still representative of the midline sample. As cautioned above, the small sample affects statistical power, and we use endline data only descriptively throughout this report.

Table 1: Baseline characteristics of midline and endline samples[5]

Variable	Midline (n=1,730)	Endline (n=293)	P-Value
Treatment	52.5%	49.9%	0.208
County (Uasin Gishu)	41.2%	41.2%	0.983
Respondent Gender (Female)**	57.0%	51.8%	0.023
Respondent Age	44	44	0.594
Completed Primary***	69.6%	73.2%	0.084
Household Members	6	6	0.281
Household Income Activities	2.5	2.5	0.372
TLU Index	2.2	2.3	0.724
Self-reported Land Size (Acres)	3.4	3.3	0.778
Timber Trees at Baseline (>50)	54.6%	55.9%	0.579
Trees at Baseline (>100)	48.3%	50.1%	0.426

[4] With an F-Statistic of 0.99 and a p-value of 0.459.
[5] *** Significant at the 1% level, ** significant at the 5% level, and * significant at the 10% level.

4.3.2 Demographic and Socio-Economic Profile

The socio-demographic profile of respondents provides context on the study population. While we collected basic demographic and socio-economic information at baseline and midline, the baseline demographic data is richer and contains detailed information on the household composition. Because we don't expect the program to impact these household characteristics in the short term, but rather have a positive impact on farmers' livelihoods once trees are mature and can be used for household consumption or to sell for profit, we report on baseline demographic and socio-economic data for all farmers that participated in the midline survey.

Table 2 **shows that the average respondent is female, in their forties, has completed primary education and lives in a relatively big household of 6 members.** The mean self-reported land size is 3.4 acres with a median of 2 acres and over four-fifths of farmers grow maize. Most farmers (80%) sell food crops and over half (60%) sell livestock for income.

However, farmers in Kericho and Uasin Gishu are systematically different in terms of demographics and socio-economics[6]. As Table 2 shows, respondents in Uasin Gishu are more likely to be female and they tend to have more advanced education than their counterparts in Kericho. Farmers in Uasin Gishu also tend to have larger farms and higher livestock ownership.

Table 2: Baseline characteristics by county[7]

Variable	Kericho (n=1,017)	Uasin Gishu (n=713)	All (n=1,730)	P-Value
Respondent Gender (Female)* **	53.9%	61.4%	57.0%	0.000
Respondent Age*	44	45	44	0.081
Completed Primary* **	66.4%	74.1%	69.6%	0.000
Completed Secondary* **	27.9%	33.9%	30.3%	0.002
Household Members	6	6	6	0.940
Household Income Activities **	2.4	2.5	2.5	0.044
Self-Reported Land Size (Acres)* **	2.5	4.5	3.4	0.000
Has Livestock **	95%	97%	96%	0.020
Grows Maize **	80.5%	84.1%	82.0%	0.023
Grows Cash Crops* **	42.1%	12.7%	30.0%	0.000
Has Grazing Land* **	75.8%	84.1%	79.2%	0.000
Sells Food Crops	80.3%	78.8%	79.7%	0.384
Sells Livestock* **	51.5%	70.9%	59.5%	0.000

[6] With an F-Statistic of 20.79 and a p-value of 0.000 running a joint significance test.
[7] *** Significant at the 1% level, ** significant at the 5% level, and * significant at the 10% level.

4.4 Data Collection

The baseline and midline data collection took place between February and March in 2019 and 2020, respectively. The baseline was conducted immediately before the Tree Program intervention and the midline was timed to take place twelve months after the intervention.

Data collection for the endline stage took place between March and May 2021. The qualitative data and tree trader study were completed first, and the quantitative phone survey took place a few weeks later

5 Findings

5.1 Tree Uses

In this section we explore data from the three points in time of the study using baseline and midline data for the overall ownership of timber trees and employing endline data to dive deeper into the uses by tree species. Additional data on overall tree uses at baseline and midline, including detailed information on the use of firewood can be found in Appendix 1.

This section responds to the research question on the uses that farmers have for the trees they grow on the land, detailing differences between tree species and quantifying uses based on endline data.

We start this section with an overview of tree ownership and a review of the midline findings of the Tree Program's treatment effects to contextualize the importance of different tree uses and follow with an overview of farmers' overall timber tree uses. Finally, we detail the uses farmers have for grevillea trees and other relevant timber tree species, contextualizing quantitative findings with qualitative insights. We focus our analysis on grevillea trees, given that the impact of the Tree Program on grevillea is the focus of this report.

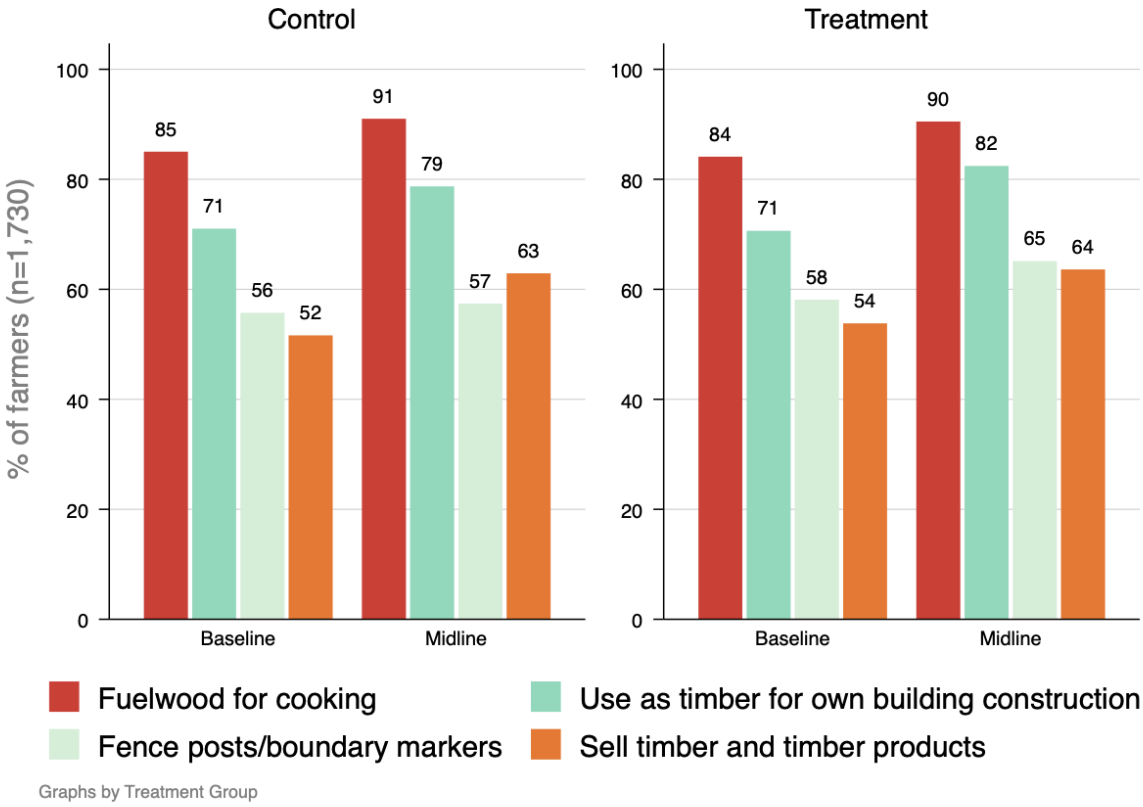
5.1.1 Timber tree ownership and planting

Most farmers across both Kericho and Uasin Gishu owned timber trees at both baseline and midline. The most common timber tree type in both counties was cypress, followed by eucalyptus and grevillea (Figure 2). In both counties, less than half of the farmers own pine trees or other timber tree species. At midline, farmers in Uasin Gishu were more likely to own timber trees overall, cypress, and eucalyptus trees. But ownership of grevillea trees was 19 percentage points higher in Kericho, a difference that was significant at the 1% level[8].

[8] See Appendix 1: Tree Uses at Baseline and Midline

Both at baseline and midline, the most common use for trees grown on the farmers' land was fuelwood for cooking (Figure 14). This holds true when considering the control and treatment group farmers individually and when separating the sample by county (Kericho and Uasin Gishu). At both points in time, the second most named use for trees was for *own building construction*. The third and fourth most common uses were *fence posts/boundary markers* and *sell timber and timber products* at baseline and midline, respectively. This information is not directly comparable to endline as the uses were asked for all trees, and not timber trees specifically.

Figure 14: Four most common tree uses – Baseline and midline



At both baseline and midline, the most common fuel source for respondents was gathered firewood (79% of farmers at midline). Farmers who use gathered fuelwood as their main fuel source at midline, report spending on average 6 hours a week gathering fuelwood and 81% state that the nearest source is trees on their own farm. The second most common fuel source at both time points is purchased fuelwood, used by 18% of the sample. Farmers who use purchased fuelwood as their main source, spent on average KES 278 per week on fuelwood at baseline, and KES 252 at midline. The median farmer spends KES 200 at both points in time.

We explore whether there are underlying characteristics associated with using purchased or gathered firewood as the main source for cooking fuel. For this analysis, we combine baseline and midline data. We run two panel logit regression models with varying dependent variables:

1) Using gathered fuelwood as the main source
2) Using purchased fuelwood as the main source.

We include demographic and socio-economic characteristics as the covariates to understand the association between explanatory variables and the outcome of interest. We look at the farmer's county of residence, age, gender, education level, household size (number of household members), Tropical Livestock Unit (TLU) index, self-reported land size and two binary variables indicating whether the household at baseline had more than 50 timber trees

or more than 100 trees (all tree species), respectively. We also control for whether the farmer is in the treatment group and the year of data collection.

The results show that having more than 100 trees at baseline and owning more livestock are positively and significantly correlated with gathering fuelwood and negatively and significantly correlated with purchasing firewood (Table 10). We find the opposite for self-reported land size, but the magnitude of this effect is small. In addition, we see that households in Uasin Gishu are more likely to use purchased fuelwood, and less likely to use gathered fuelwood compared to households in Kericho. This is in line with our findings on socio-economic characteristics of households in the two counties. Farmers in Uasin Gishu own larger farms, have higher educational attainment and engage in more income-generating activities.

Table 10: Determinants of firewood as main cooking fuel

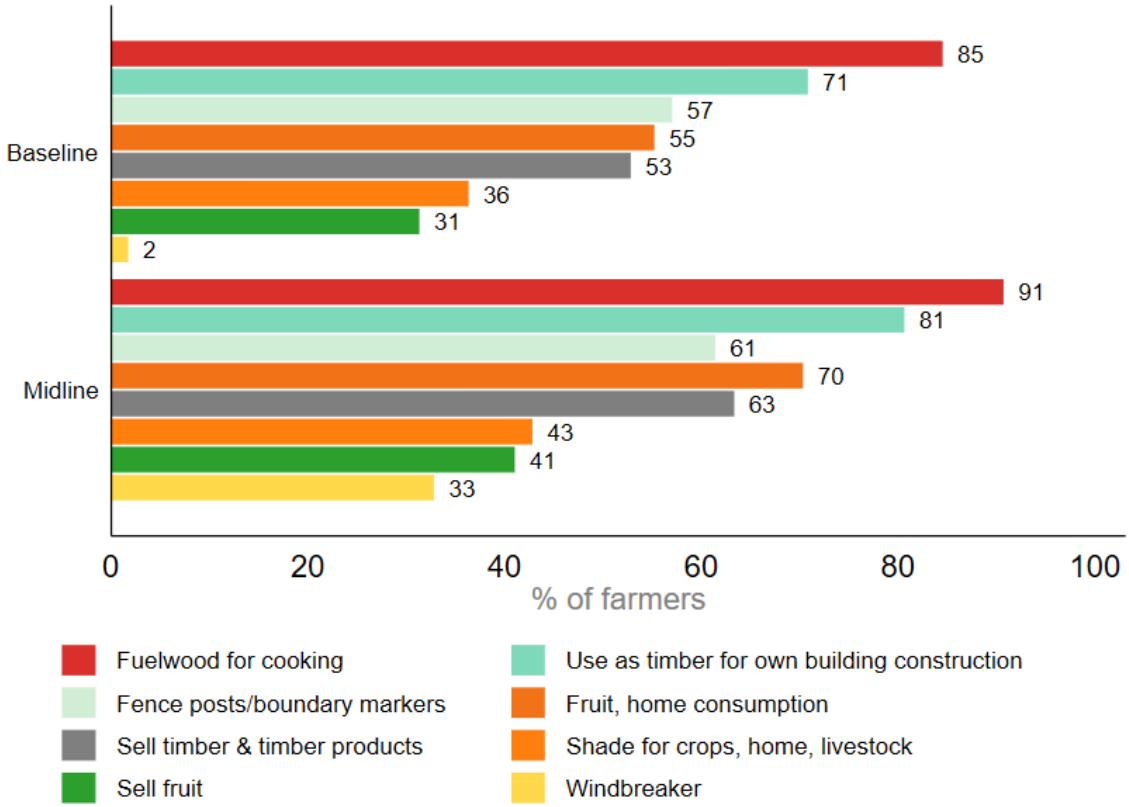
	Coefficient (Std. Error)	
	(1) Gathered fuelwood	**(2) Purchased fuelwood**
Treatment	0.02 (0.01)	-0.01 (0.01)
Year (2020)	0.04*** (0.01)	-0.03*** (0.01)
Uasin Gishu	-0.05*** (0.02)	0.03** (0.01)
Respondent Age	0.00 (0.00)	-0.00 (0.00)
Respondent Age Squared	0.00 (0.00)	-0.00 (0.00)
Respondent Female	-0.02 (0.01)	0.01 (0.01)
Household Members	0.00 (0.00)	0.00 (0.00)
TLU Index	0.02*** (0.00)	-0.02*** (0.00)
Completed Primary Education	0.02 (0.02)	-0.02 (0.01)
Self-reported Land Size	-0.00** (0.00)	0.00** (0.00)
More than 50 Timber Trees at Baseline	-0.01 (0.02)	0.01 (0.02)
More than 100 Trees at Baseline	0.05** (0.02)	-0.04** (0.02)
No. of observations	**3,437**	**3,437**

In addition to firewood for own consumption, seven other uses were named by more than 30% of the farmers at baseline and midline for timber trees:

- Use as timber for own building construction
- Fruit (home consumption)
- Fence posts / boundary markers
- Sell timber & timber products
- Shade for crops, home, livestock
- Sell fruit
- Windbreaker

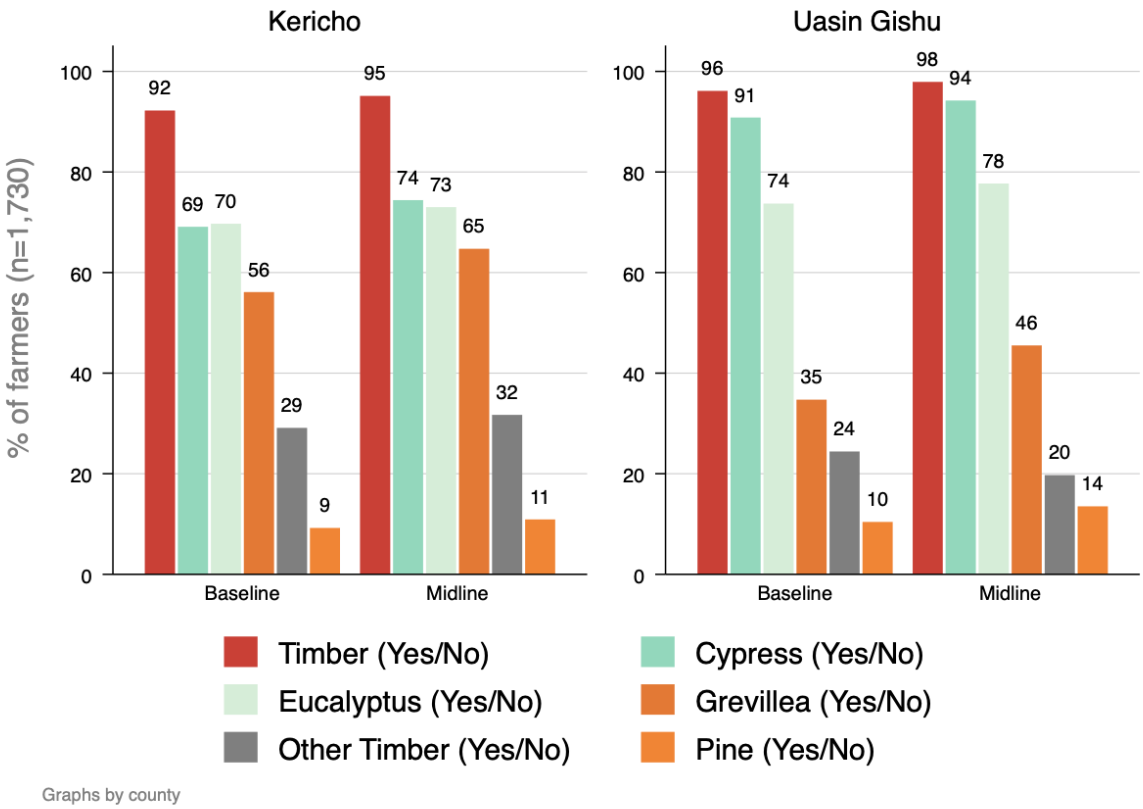
Between baseline and midline, there were only limited changes (see **Figure 15**).

Figure 15: Change of important uses over time



Appendix 2 for the differences in tree ownership at midline by county.

Figure 2: Timber tree ownership over time by county



A greater proportion of farmers in Uasin Gishu planted timber trees in the 12 months preceding the midline survey compared to Kericho; farmers in Kericho, however, were more likely to plant grevillea trees.[9] Table 3 shows the mean and median number of trees

[9] **See** Figure 16 **in** **Appendix 1: Tree Uses at Baseline and Midline**

Both at baseline and midline, the most common use for trees grown on the farmers' land was fuelwood for cooking (Figure 14). This holds true when considering the control and treatment group farmers individually and when separating the sample by county (Kericho and Uasin Gishu). At both points in time, the second most named use for trees was for *own building construction*. The third and fourth most common uses were *fence posts/boundary markers* and *sell timber and timber products* at baseline and midline, respectively. This information is not directly comparable to endline as the uses were asked for all trees, and not timber trees specifically.

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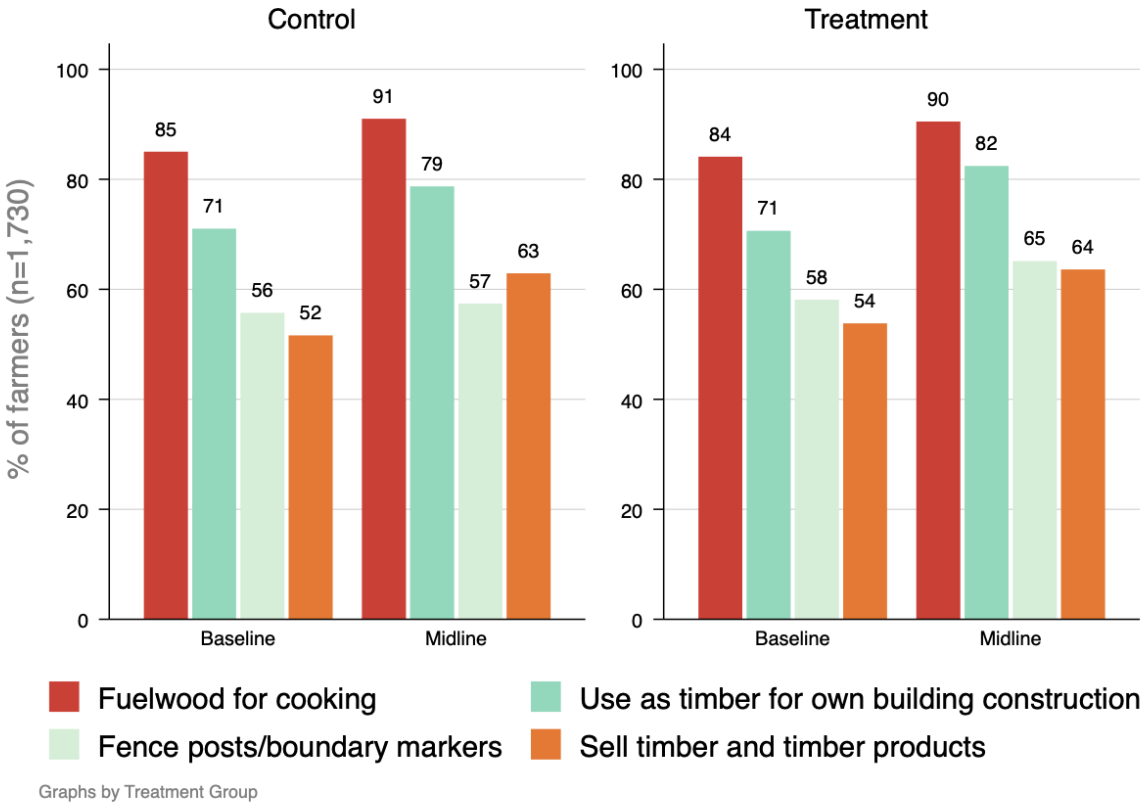

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or more than 100 trees (all tree species), respectively. We also control for whether the farmer is in the treatment group and the year of data collection.

The results show that having more than 100 trees at baseline and owning more livestock are positively and significantly correlated with gathering fuelwood and negatively and significantly correlated with purchasing firewood (Table 10). We find the opposite for self-reported land size, but the magnitude of this effect is small. In addition, we see that households in Uasin Gishu are more likely to use purchased fuelwood, and less likely to use gathered fuelwood compared to households in Kericho. This is in line with our findings on socio-economic characteristics of households in the two counties. Farmers in Uasin Gishu own larger farms, have higher educational attainment and engage in more income-generating activities.

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No. of observations	**3,437**	**3,437**

In addition to firewood for own consumption, seven other uses were named by more than 30% of the farmers at baseline and midline for timber trees:

planted for all timber trees, cypress, grevillea, and eucalyptus. The average number of overall timber trees planted in Uasin Gishu was higher than in Kericho, and this was led by a higher number of cypress trees planted in this county, where the median farmer planted 20 eucalyptus trees.

- Use as timber for own building construction
- Fruit (home consumption)
- Fence posts / boundary markers
- Sell timber & timber products
- Shade for crops, home, livestock
- Sell fruit
- Windbreaker

Between baseline and midline, there were only limited changes (see **Figure 15**).

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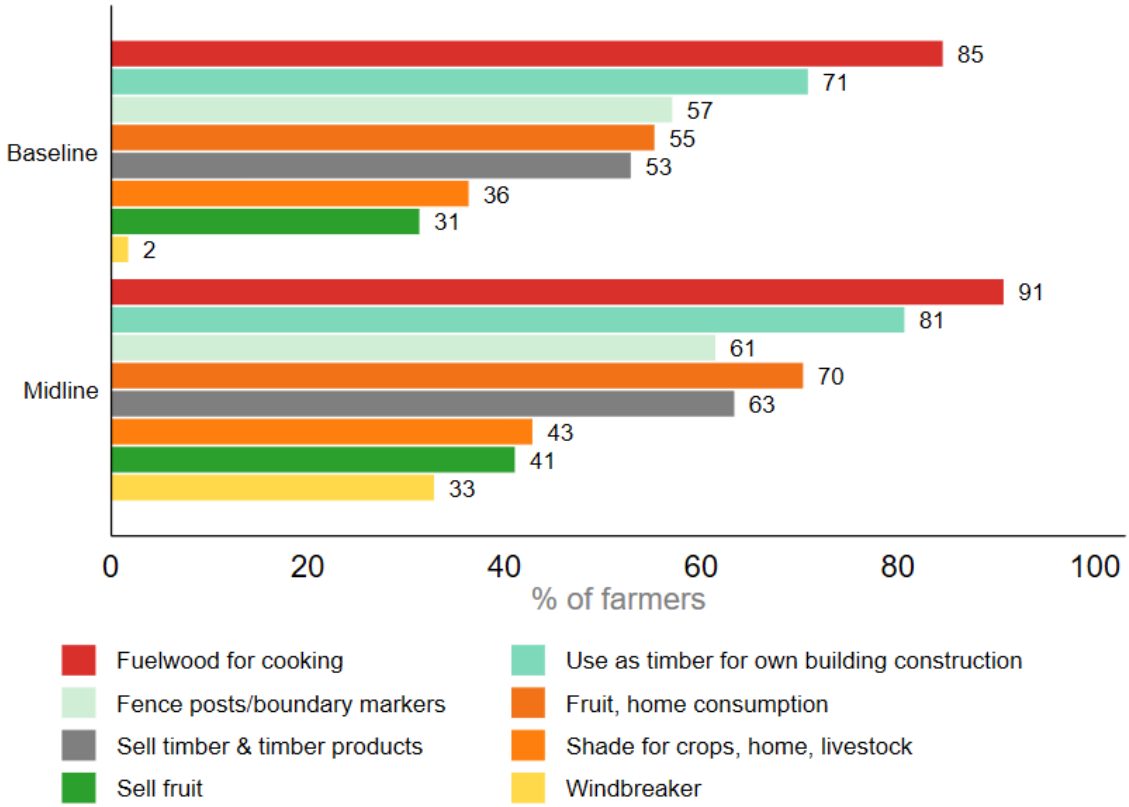


Appendix 2.

Table 3: Number of timber trees planted at midline by county

# of trees planted in the last 12 months	Kericho	Uasin Gishu	All
All Timber			
Mean	**56.7**	**73.6**	65.1
Median	**20**	**30**	25
[95% CI]	[45.3-68.1]	[62.2-84.9]	[56.0-72.2]
n	496	390	886
Cypress			
Mean	**36.0**	**56.3**	46.9
Median	**15**	**20**	20
[95% CI]	[25.2-46.8]	[47.1-65.6]	[39.7-54.1]
n	276	323	599
Eucalyptus			
Mean	50.1	42.0	46.8
Median	15	15	15
[95% CI]	[35.1-65.1]	[25.9-58.2]	[35.9-57.8]
n	229	156	385
Grevillea			
Mean	24.8	33.6	27.7
Median	**10**	**10**	10
[95% CI]	[19.0-30.5]	[20.3-49.8]	[21.7-33.8]
n	207	103	310

The One Acre Fund Tree Program had a positive and statistically significant treatment effect on whether farmers planted grevillea trees and the number of grevillea trees planted in the past 12 months. Farmers in the treatment group were on average 15.6 percentage points more likely to plant grevillea trees in the past 12 months. The average treatment effect on the number of trees planted was 7 grevillea trees. The average treatment effect on the treated, referred to as the local average treatment effect (LATE) was 22.0 percentage points higher likelihood of planting and grevillea trees in the past 12 months and 11 additional trees for partial compliers[10] and 26.9 percentage points and 13 trees for full compliers[11]. The treatment effects were higher in Uasin Gishu compared to Kericho, where the average treatment effect was a 21-percentage point increase and an 8 tree increase for whether grevillea trees were planted and the number of grevillea trees planted, respectively.

[10] A treatment farmer either received the kit but failed to attend the training or did not receive the kit but attended the training.
[11] A treatment farmer who received the grevillea tree kit and attended the tree training.

When considering overall timber tree planting, i.e., irrespectively of the species, the program had no significant effect.

Overall, treatment farmers, especially in Uasin Gishu, will be able to benefit the most from tree uses assigned to grevillea, given the high treatment effect in the planting and number of new grevillea trees planted. Nonetheless, most farmers across both counties have high timber tree ownership, especially of cypress and eucalyptus. Additionally, while the treatment effect of the program was lower in Kericho, grevillea ownership is still higher in this county compared to Uasin Gishu at midline.

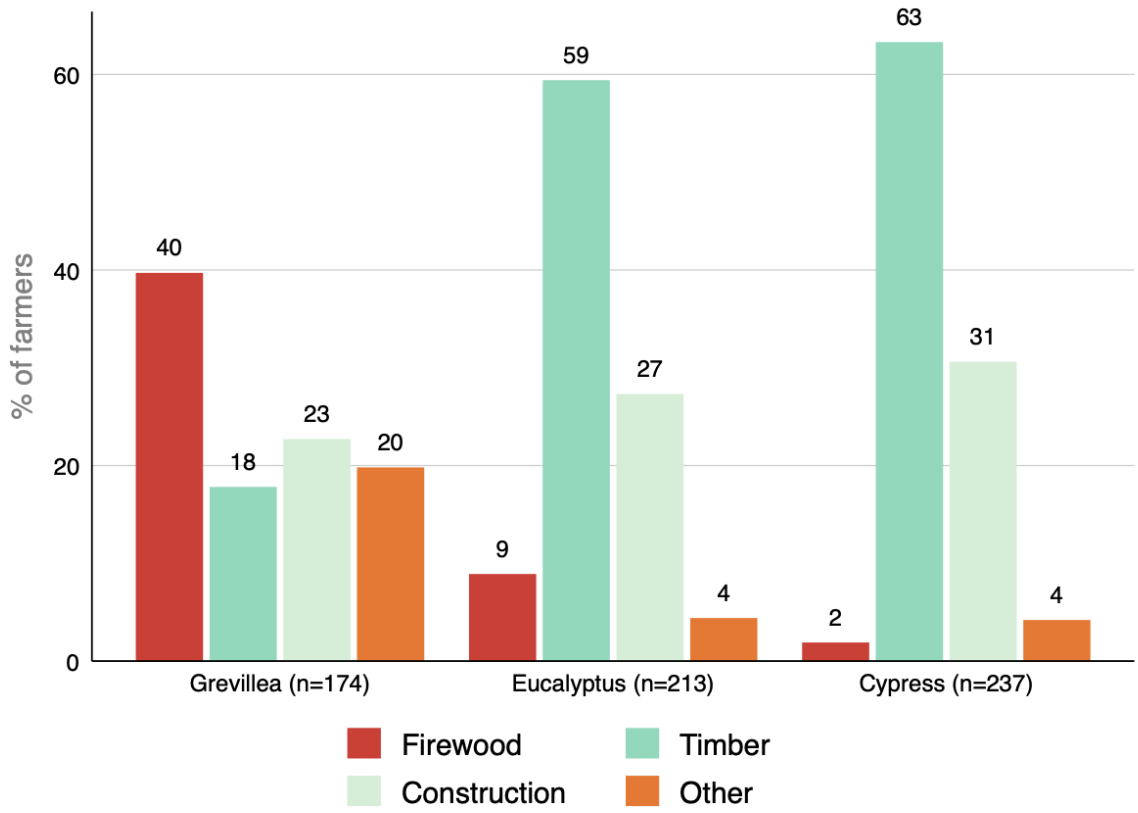
5.1.2 Use by tree type

At endline, we asked farmers questions about their uses of the five timber tree groups in our research scope: grevillea, eucalyptus, cypress, pine, and other timber. We also asked questions about young (planted since 2019) grevillea trees specifically, which is the focus of the 1AF Tree Program. Out of all households in the endline sample, 11% report being pine growers, 59% grow grevillea trees, 19% confirm having planted grevillea trees since 2019, 73% grow eucalyptus, 81% grow cypress, and 24% grow other timber tree species. Because the endline sample is much smaller than baseline and midline, the results presented here are only indicative. This holds especially for the species that are less represented among the farmers, i.e., pine and other timber trees. Our analysis focuses on three main species: cypress, eucalyptus, and grevillea.

The most important uses for timber trees to the farmers varied between the species, as seen in Figure 3[12]. For grevillea trees, farmers rank firewood (for own consumption or sale) as the most important use of the species. For eucalyptus and cypress, however, selling trees as timber is ranked as the most important use for the majority of the farmers. For all three species, using the timber for own building construction is the second most important use. For grevillea, other most important uses include soil improvement (12%) and shade for crops (4%). For eucalyptus and cypress, other most important uses are making fence posts with 4% and 3% of the species owners marking this as the most important use, respectively.

[12] At endline, we asked each farmer who grew a tree species to name all the uses they had for each species and then to rank them in order of importance. Figure 3 shows the three uses most commonly ranked first for each timber tree species of interest.

Figure 3: Most important tree uses by species, endline

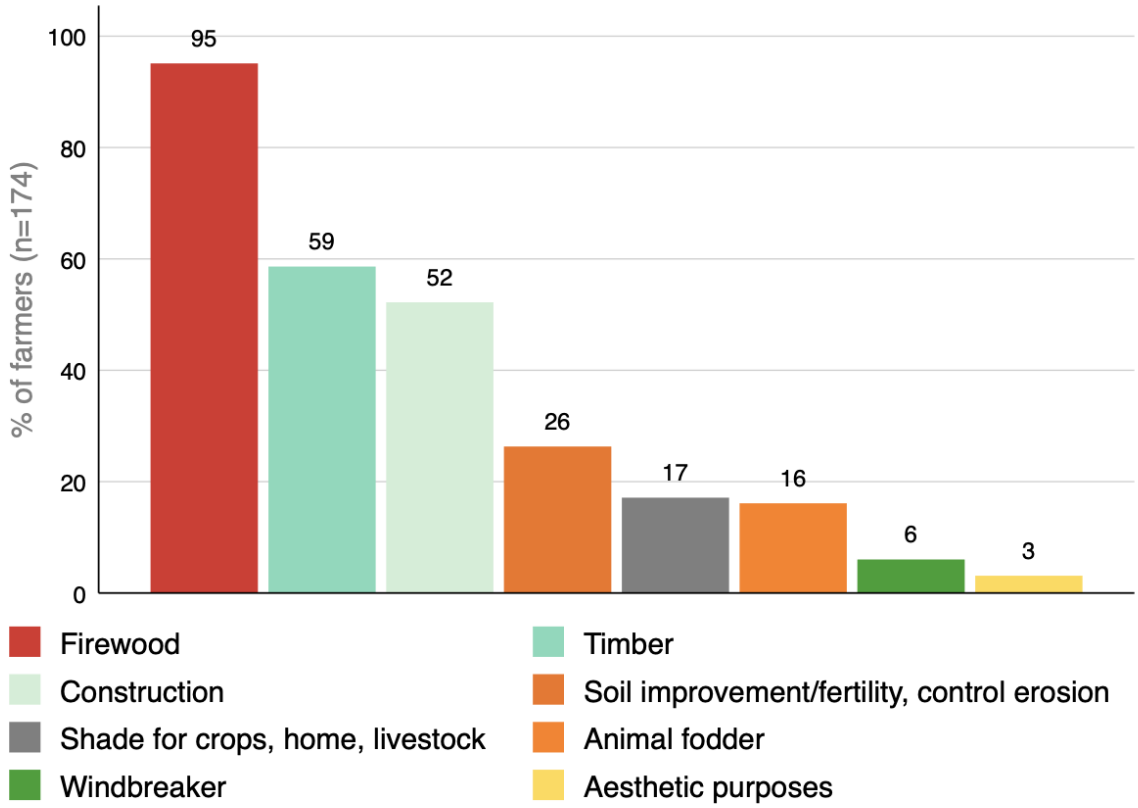


The following section focuses on firewood for grevillea trees, and construction and timber for eucalyptus and cypress. We note that the proportion of farmers who use their trees to make charcoal either for own consumption or sale is negligible across all tree species.

5.1.2.1 Use of grevillea trees

When asked about the overall uses of their grevillea trees, 95% of grevillea growers report using the species for firewood (either for own consumption or sale), 59% use it for selling (timber or branches) and 52% for construction (of structures or furniture), as can be seen in Figure 4. Overall, 91% of grevillea growers mention firewood *for own consumption*, while 17% mention firewood *for sale*. The second most common use, mentioned by 58% of the farmers is selling grevillea *as timber*, while 7% sell the *branches* of their grevillea trees. Almost half of the farmers (46%) use grevillea for *own construction* and 14% use the trees to make furniture. Over a quarter (26% of the farmers) mention soil improvement as a use for grevillea trees. Other uses mentioned by over 10% of the farmers are i) shade for crops, ii) animal fodder, and iii) environmental conservation.

Figure 4: Uses for grevillea trees



Farmers at endline were also asked how many grevillea trees they need on average per year for their three most important uses.

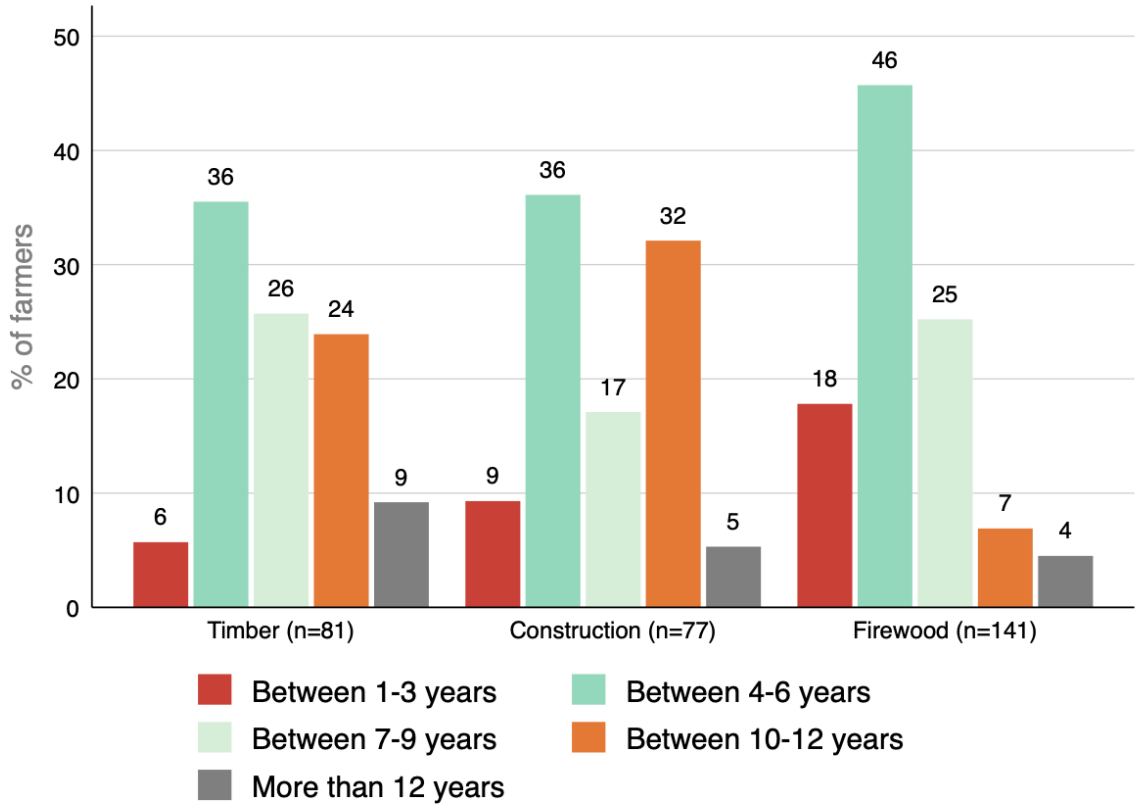
Farmers who rank firewood as one of the three most important uses for grevillea trees need on average 6 (median 3) grevillea trees for firewood per year[13]. To sell as timber, farmers need on average 9 (median 5) grevillea trees per year, and for using it as timber for own building construction farmers require on average 6 (median 3) grevillea trees per year.

Additionally, farmers were asked the minimum age that a tree needed to be in order to be used for their three most important uses.

For firewood, younger trees are used (for most farmers between one and six years). As the grevillea trees mature, there seems to be a change in use case. Older trees are used for timber, either for sale or for own building construction. Since the average treatment effect is 7 additional grevillea trees, the treatment can in the short term free up resources previously spent on firewood, and in the long term generate income through sale of the trees as timber or free up resources previously spent on timber for own building construction.

[13] We note that while a single tree might have more than one use, farmers were asked about how many trees they needed in a year to satisfy a specific need/ usage.

Figure 5: Tree-age ranges for grevillea tree uses



Findings from qualitative discussions corroborate the quantitative findings. While discussing the uses of grevillea, FGD participants stated that it is mostly used for fuelwood, constructing temporary structures such as shops, for sale (particularly to coffin makers), and for charcoal making. Participants noted that the wood dries faster and is therefore good for fuelwood and making charcoal. In addition, both farmers and key informants argue that grevillea trees are excellent trees for intercropping and can be used for soil erosion control. The trees are usually planted with other crops, including coffee, and provide shade to avoid drying.

Box 1: Grevillea uses

"Mostly [grevillea] it's used as firewood and its timber is sold to those people who make coffins." (Farmer, control)

"Grevillea is for firewood and also it's good because it does not affect other crops and helps in soil fertility." (Farmer, treatment)

"Used for firewood, its leaves are good for soil fertility, can be used to feed cows, it can be sold for coffin making." (Farmer, control)

"It does not affect other crops and helps in soil fertility." (Farmer, treatment)

"I will cut it to get timber for building and sale and also for firewood." (Farmer, treatment)

However, grevillea trees are deemed inferior to other timber trees for building. Farmers stated that grevillea is too soft to build houses or furniture and that the dried wood is prone to be attacked by termites.

Box 2: Grevillea for construction

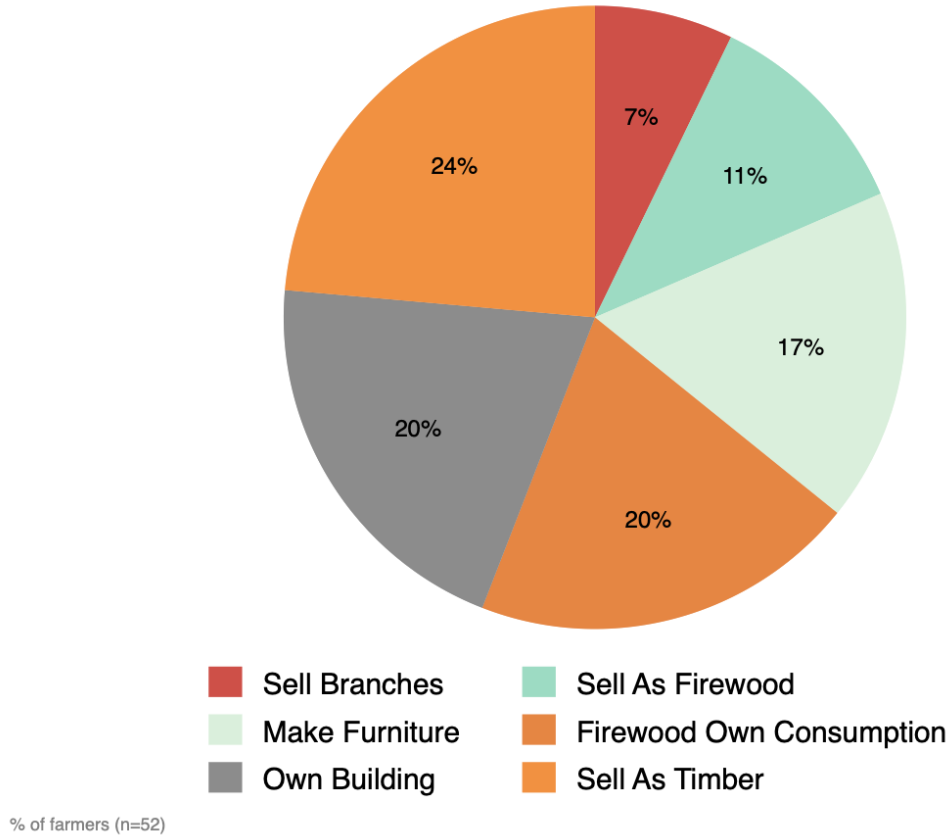
"Grevillea wood is easily attacked by termites compared to wood from blue gum (eucalyptus) and cypress, so it's mostly used for firewood." (Farmer, treatment)

"Used to make ceiling boards and cardboards but when used for building it's not strong because it is eaten by termites." (Farmer, control)

5.1.2.2 Use of *young* grevillea trees

Farmers who have recently planted grevillea trees intend to use in the future, on average, 31% for selling (24% as timber and 7 % as branches), 31% for firewood (20% for own consumption and 11% for selling), and 37% for construction (20% for own building and 17% to make furniture) (Figure 6)[14]. These findings signal that while firewood is the most important use for grevillea trees, it is less tree-intensive than other uses, such as using timber for construction.

Figure 6: Allocation of young grevillea trees



[14] We note that farmers may have multiple uses for a single grevillea tree. We asked farmers to list the main use that they would have for a given tree and omit secondary uses in the survey, for simplicity.

5.1.2.3 Cypress

Over four fifths (84%) of the respondents who grow cypress trees select using them as for construction of buildings or furniture among the three most important uses. The second and third most important uses are to sell as timber or branches (77%) and for firewood (36%), respectively.

Qualitative findings confirm that cypress wood is used extensively for building. FGD participants and KIs argue that cypress wood can be used to build houses, stores, furniture, and coffins. However, cypress grows slowly and cannot be planted with other crops as it will take nutrients away and is not suitable as firewood as it takes a long time to dry. One farmer mentioned that cypress bark can be used to tie grass heaps.

Box 3: Cypress uses

"*I would like cypress because it is good for building compared to grevillea that has no good timber, people prefer cypress than grevillea because it has good timber.*" (Farmer, treatment)

"*I like cypress, but the problem is that it grows slowly.*" (Farmer, control)

"*Cypress and blue gum affect other crops, so grevillea does not affect.*" (Farmer, treatment)

"*Mostly cypress is used to fence compounds and grows much slower and cypress is not used for firewood, cypress is not good for firewood.*" (Farmer, control)

"*Would like cypress because I can use its timber for building and also you can sell its timber to pay school fees, I sold cypress in 2019 and I used the money to pay school fees for my children.*" (Farmer, control)

"*Cypress because its branches are used for fencing and for firewood, its trunk you cut for timber and does not need a lot of care.*" (Farmer, treatment)

5.1.2.4 Eucalyptus

For eucalyptus growers, the most important use on average is selling as timber (75%), followed by using the tree as timber for own construction (71%) and firewood (62%). Similarly, participants in the qualitative interviews mention that eucalyptus is used for building and fencing. However, most farmers were emphatic that eucalyptus needs to be grown away from other crops and water sources. Some farmers preferred selling grevillea branches as firewood or cypress trees and buying eucalyptus timber with the proceeds, rather than planting it directly on their fields.

Box 4: Quotes on eucalyptus use

"Although blue gum [eucalyptus] grows fast and is good for building and posts, for now the government is discouraging the planting of blue gum because it dries the rivers and water sources and also affects other crops." (Farmer, control)

"Blue gum is good for timber, can sell posts and also use as firewood." (Farmer, treatment)

5.1.2.5 Other timber

A subset of farmers (24%) reported growing other timber tree species on their land at endline. In total, we identified 36 distinct species in addition to cypress, eucalyptus, grevillea, and pine. The most common is Broad Leafed Croton, mentioned by 33 farmers, followed by Red Stinkwood which is grown by 17% of the farmers who grow timber trees other than the four main species on their land.[15]

The most common uses for other timber trees are firewood for own consumption, use as timber for own building construction, and make charcoal for own consumption.

5.2 Willingness to Pay

In this section, we explore the willingness to pay (WTP) of farmers for different tree species, focusing on cypress, eucalyptus and grevillea. We start by describing the WTP approach we took for this study, then provide an overview of the WTP for the most important tree uses, and finally, model the WTP for a given tree of each species, by the age of the tree.

This section responds to the research questions around tree pricing and demand by describing the prices that farmers would assign for each tree and each use case, even for usages where farmers do not necessarily buy or sell trees for.

We note that for this section we remove extreme outliers (above the 95th percentile) on tree values from the analysis. Extreme outliers are most likely to be recall- or typing errors and affect the overall distribution of values, especially in regards to means and confidence intervals.

5.2.1 Willingness-to-Pay Approach

To obtain a range of values for the most important uses by species, we asked farmers how much they would be willing to pay for one tree that was to be used for a specific use, if the farmer were to buy the tree instead of growing it on their land. We recorded their responses as willingness to pay[16].

There is a risk of 'anchoring', where a given answer is inadvertently influenced by a question that is asked earlier in the survey. This may, for example, affect the declared WTP for the second and third most important uses by species, as the first question for each tree species asks about the WTP of the most important use. This may also affect the declared

[15] Table 13 in the Appendix 4 lists all other timber tree species which were mentioned by the farmers.

[16] These questions were only asked for the three most important uses. Therefore, the average WTP for farmers who did not select the use among their three most important uses might be lower. Hence, the overall average of WTP for a specific use is likely to be lower.

WTP for uses of tree species that were asked later; the order of the species was: pine, grevillea, eucalyptus, cypress, and other timber trees[17]. Secondly, farmers may have a virtual budget constraint in their mind, thus committing to buy the most important use or the earlier-named species at a higher rate may make them less willing to also pay for less important uses or other timber species.

Further, the WTP we estimate may be contingent on specific survey and contextual characteristics. For example, these could include the time of the year during which the survey took place and the related meteorological conditions, and the way in which the enumerators presented the questions. This could mean that a similar survey administered in a different period of the year with a slightly different approach may reveal a different average WTP for similar uses. Some of the survey characteristics (such as the recent meteorological conditions) may potentially also affect different groups of respondents in different ways.

Moreover, there may be a difference between stated and actual preferences. It is very difficult to estimate the extent to which the declared farmers' WTP would translate into the actual demand for the indicated uses and species. However, in Table 6 in section 5.3.2 we see that the earnings per tree species move in a similar range as the WTP indicated by farmers.

5.2.2 Willingness to Pay for Tree Uses

We note that the willingness to pay is influenced by the study context. Out of all households in the endline sample, 59% grow grevillea trees, 73% grow eucalyptus, 81% grow cypress. Further, at baseline and midline, around a quarter (24%) of farmers had sold cypress and eucalyptus trees, while only 6% of the farmers had sold grevillea trees in the past 12 months. Finally, 79% of tree traders in the area buy cypress, 77% buy eucalyptus, and 19% buy grevillea. Thus, we expect the estimations to be most precise for cypress and eucalyptus, given that these tree species are widely grown and commercialized, while grevillea trees are grown by a lower percentage of farmers and the trees are not widely monetized.

Figure 7 shows the distribution of the farmers' WTP for each tree species for timber sales, own construction, and firewood (sales and own consumption). The median (or 50th percentile) is represented by the center line inside the boxplot. The right and left of the 'box' represent upper and lower quartiles, respectively. The T-lines extending from the top and bottom of the boxplot represent the maximum and minimum ages. Outliers are represented as dots at either end of the boxplot.

In general, the WTP tends to be similar for timber and construction, but lower for firewood. The exception is for cypress, which has a clearly higher valuation for timber compared to construction, as detailed below.

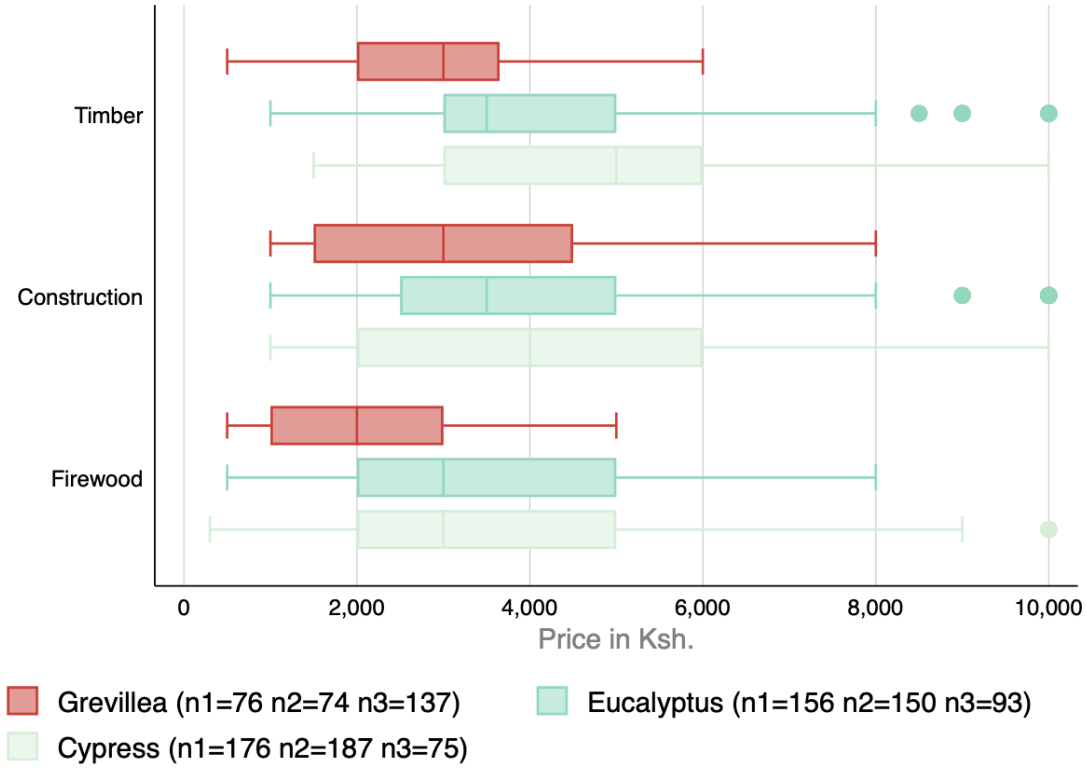
Regardless of the use case, cypress tends to be the highest-valued tree species. The median price for eucalyptus is the same as for cypress for firewood, but it is lower than cypress

[17]The risk of anchoring is somehow mitigated by the survey structure. While the question order was not randomized, the sample contained farmers with different combinations of tree ownership, leading to 47% of the farmers being asked about grevillea first, 26% about eucalyptus first, 12% about pine first, and 12% about cypress first. Similarly, farmers were asked about their WTP for tree usages within a tree species based on their ranking of the usage. In the case of grevillea, 39% were asked about firewood first, 23% about construction first, 20% about other uses first and 18% about timber first.

for timber sales and construction. Cypress receives the highest valuation for timber sales at a median of KES 5,000, followed by construction (KES 4,000), and firewood (KES 3,000).

Grevillea is valued the lowest for all three usage cases. The valuations for grevillea stand at a median of KES 3,000 (average KES 2,865) for timber sales, a median of KES 3,000 (average KES 2,967) for construction, and a median of KES 2,000 (average KES 2,409) for firewood. It is important to note that in general, we have relatively few observations per usage case and these vary widely be species.

Figure 7: WTP of farmers for firewood for own consumption and for sale



5.2.3 Willingness to Pay by Tree Species

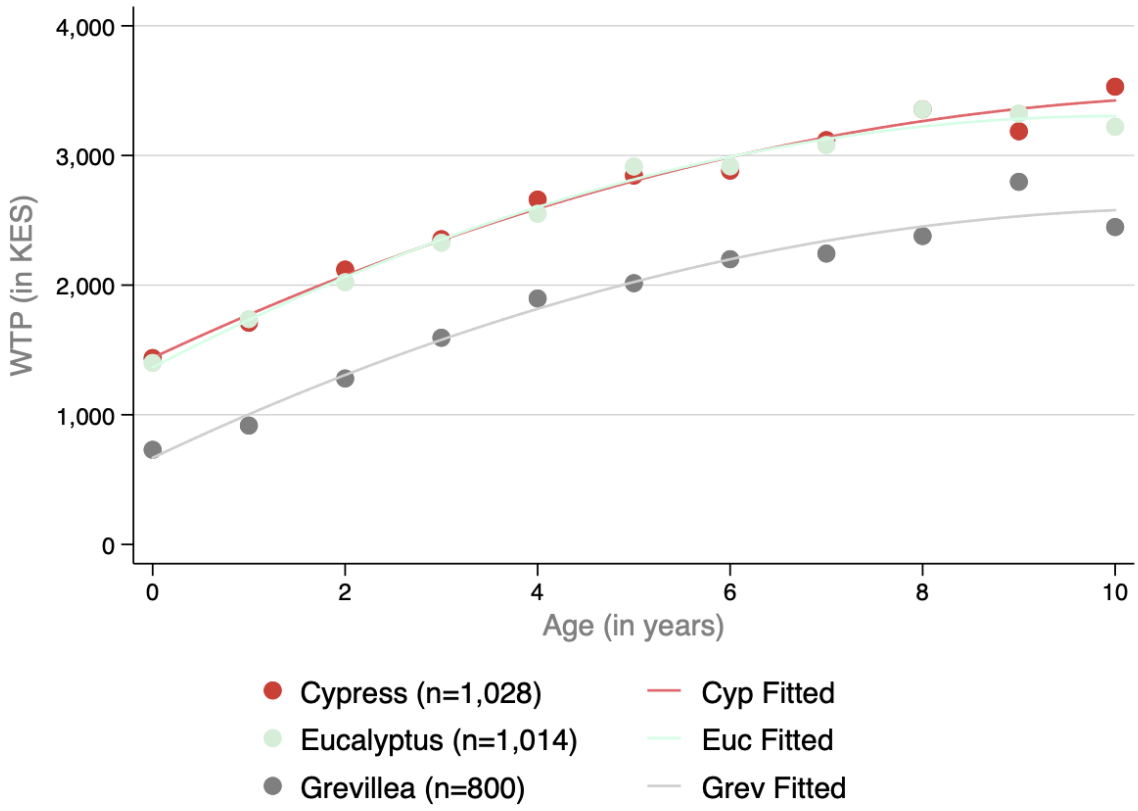
To explore the WTP for each evaluated tree species, we use the full range of answers to the WTP module for each species and model the WTP by age for each tree. We build a quantile regression model by combining (appending) all the information we have on each tree type, age range, and usage. We then simplify the usage into four categories (timber sales, construction, firewood, and other) for simplicity. Thereafter, we estimate the *median* price per type and age[18]. Overall, this model provides us with almost 3,000 observations[19], and while

[18] The model consists of Monte-Carlo simulations that randomly pick tree uses and the value assigned to a tree at each age. We use simulations to account for the fact that for some tree uses (e.g. construction) a whole tree needs to be harvested and there is no future monetary value from it, while other uses (e.g. firewood) allow for trees to still be monetized after being used.
[19] The number of observations for each tree type is well distributed among species, see Figure 8.

the data is still approximate, appending information on each tree-usage pair provides us with sufficient observations on each individual tree type, usage type and age group.

The model shows that farmers' *median* WTP for each tree type increases as trees age, but the WTP peaks at year five or six and then stagnates (Figure 8)[20]. Further, the model predicts very similar WTP trends for cypress and eucalyptus and much lower values for grevillea trees. For eucalyptus, the values range between KES 1,400 and KES 3,220. Farmers are willing to pay between KES 730 for a newly planted grevillea tree and a maximum of KES 2,800 for a 9-year-old tree. We note again that this model uses median values and not average values and the values differ to section 4.2.2. because we include "other" tree uses in this model and account for different willingness to pay for varying tree ages.

Figure 8: WTP by tree species



5.3 Demand and Supply of Timber Trees

This section responds to research questions around the demand and pricing for grevillea and other timber trees. The analysis explores data from all three time points of the study, including the tree trader survey[21], and focuses on grevillea, cypress and eucalyptus.

[20] The value estimations for each tree species and age can be found in Appendix 7.
[21] As part of the tree trader survey, 277 respondents were interviewed. 26% are local furniture makers, 20% are local timber yard owners or managers, 17% are charcoal sellers and 10% each are fuelwood dealers, tree brokers, and farmers. The remaining 7% are either church or school managers.

We note that both the tree trader- and the endline data consist of small sample sizes, the following results should therefore be considered as descriptive, and are not the result of regression analysis, except when specified.

We note that we also remove extreme outliers (95th percentile) for any value observations in this analysis.

5.3.1 Demand

We look at the demand for timber trees from two perspectives. First, we look at the assessment from tree traders in terms of sourcing of trees and the uses for the trees they procure. Second, we look at the farmers demand for timber trees by exploiting endline data.

5.3.1.1 Tree Traders

In terms of sourcing, 34% of traders buy their trees from tree brokers (who buy from tree/timber owners), but most respondents (60%) buy their trees directly from the owner: individual farmers, commercial tree planters or tree plantations.

When buying directly from the owner, 79% of tree traders buy cypress, 77% buy eucalyptus, 25% buy pine, and 19% buy grevillea. Most traders buy multiple species from the owner – but when asked to choose the one species they prefer for the given market price, 56% indicate cypress trees, followed by 31% for eucalyptus. Only 2% appreciate grevillea trees in terms of value for money.

Over a third (36%) of the interviewed traders sell timber trees, while the remaining 74% of traders use the trees to make and sell furniture and other wood/charcoal products. Out of those who do sell trees, 67% prefer selling cypress, 21% prefer selling eucalyptus, and 5% prefer selling grevillea. Reasons for preferring selling cypress trees include it having greater demand as well as greater profit. The same reasons apply to traders who prefer selling eucalyptus trees, in addition to eucalyptus growing fast so the trader never runs out of stock. Given only 5 tree traders prefer selling grevillea trees, we are not able to make any assessments on their reasons.

Looking at the demand of the tree traders' clients, cypress is the most preferred species: it is preferred by 61% of carpenters, 86% of timber yards/timber companies, and 84% of builders/construction clients.[22] Cypress is preferred because it produces quality timber, and in the case of timber yards/timber companies because it also has a higher resell value (in addition to producing quality timber).

The main factors tree traders use in deciding the price they are willing to pay to the tree seller are tree height and tree species, indicated by 40% and 39% of tree traders, respectively. This is followed by tree circumference (25%) and tree diameter (16%). Tree age is only the fifth-most named factor (15%).

5.3.1.2 Farmers

Currently, farmers' demand for trees is not saturated: 95% of farmers at endline are interested in planting more timber or fruit trees in the next year. Out of those, 63% plan

[22] The sample size of this question is small. The questions on carpenters, timber yards/timber companies and builders/construction clients were answered by 38, 50, and 57 tree traders, respectively.

to plant more grevillea trees, 35% plan to plant more eucalyptus trees and 61% plan to plant more cypress trees.[23]

The demand for planting trees within the next twelve months is highest for cypress trees. Farmers at endline report that they would on average plant 155 cypress, 115 eucalyptus, and 111 grevillea trees. The median farmer would plant 50 trees of each of the three species (Table 4).

Table 4: Demand for planting trees in the next year

	Cypress	Eucalyptus	Grevillea
Interest in planting more trees in the next 12 months?			
Yes	62%	35%	63%
No	38%	65%	37%
n	278	278	278
How many trees?			
Mean	155	115	111
Median	50	50	50
n	171	101	173

5.3.2 Supply

For the supply side, we consider the farmers' perspective. We first look at the farmers' intentions for harvesting timber trees, then assess intended prices and ages to sell tree species of interest, and finally look at the actual earnings made through the sale of timber trees.

We finalize this section by modelling the earnings for a given tree species by the age of the trees. While we use the full baseline and midline sample for this model, few farmers sold trees in the 12 months preceding the baseline and midline data collection stages. Thus, the model uses relatively few observations, compared to the full sample.

5.3.2.1 Tree Harvesting

Around two thirds of farmers who owned cypress, grevillea, and eucalyptus intended to eventually harvest the whole tree at endline (Table 5). On average, farmers stated that they would harvest between six and seven trees out of ten. More than three quarters of eucalyptus and cypress owners would harvest the trees to sell them. For grevillea, less than two thirds (60%) intend to harvest their trees for selling.

Intended sales prices for trees are highest for the cypress variety (Table 5). This is in line with the findings on WTP presented above. The average intended price is KES 5,651 for a cypress (median KES 5,000), KES 4,526 for a eucalyptus (median KES 4,000), and KES 3,023 for a grevillea tree (median KES 3,000). On average, farmers intend to harvest their trees when they are between seven and nine years old, independent of the tree species. We

[23] 0.5% plan to plant more pine trees and 6% plan to plant other timber trees.

note that farmers might over-estimate the price that they can sell harvested trees for and the prices given for this section are higher than the farmers' WTP and the actual earnings from selling trees in the past.

Table 5: Timber tree harvest

	Cypress	Eucalyptus	Grevillea
Harvest whole tree?			
Yes	65%	66%	61%
No	35%	34%	39%
No. of observations	**237**	**213**	**174**
Number of trees (out of 10)			
Mean	7.1	7.1	6.3
Median	8	7	6
No. of observations	**153**	**142**	**104**
Harvesting to sell?			
Yes	75%	77%	60%
No	25%	23%	40%
No. of observations	**153**	**142**	**104**
Age (in years)			
Mean	**7-9**	**7-9**	**7-9**
Median	**10-12**	**4-6**	**4-6**
No. of observations	**153**	**142**	**104**
Intended price (KES)			
Mean (at mean age)	5,651	4,526	3,023
95% CI	[5,170;6,132]	[4,040;5,011]	[2,717;3,330]
Median	5,000	4,000	3,000
No. of observations	**140**	**135**	**99**

5.3.2.2 Tree Selling

A third (30%) of farmers at baseline, and 28% of farmers at midline had sold timber trees in the preceding twelve months. Farmers at baseline sold on average 15 cypress trees, 23 eucalyptus trees and 7 grevillea trees. Farmers at midline sold on average 14 cypress trees, 14 eucalyptus trees and 6 grevillea trees.

Earnings per tree between baseline and midline remain relatively stable for each species and the median price per tree is the same for all species across time (Table 6)[24]. Overall, farmers were able to fetch higher prices for eucalyptus with an average of KES 2,268 (median of KES 2,000), than for cypress (average KES 1,998, median KES 1,500) and grevillea (average KES 2,108 and median KES 2,000). Eucalyptus trees were on average 8 years old (median of 6), cypress trees 10 years old (median of 10) and grevillea trees 10 years old (median of 7).

[24] We note that the number of observations per tree species is relatively low compared to the sample size at baseline and midline, because only a fraction of the farmers had sold trees in the past 12 months in each period.

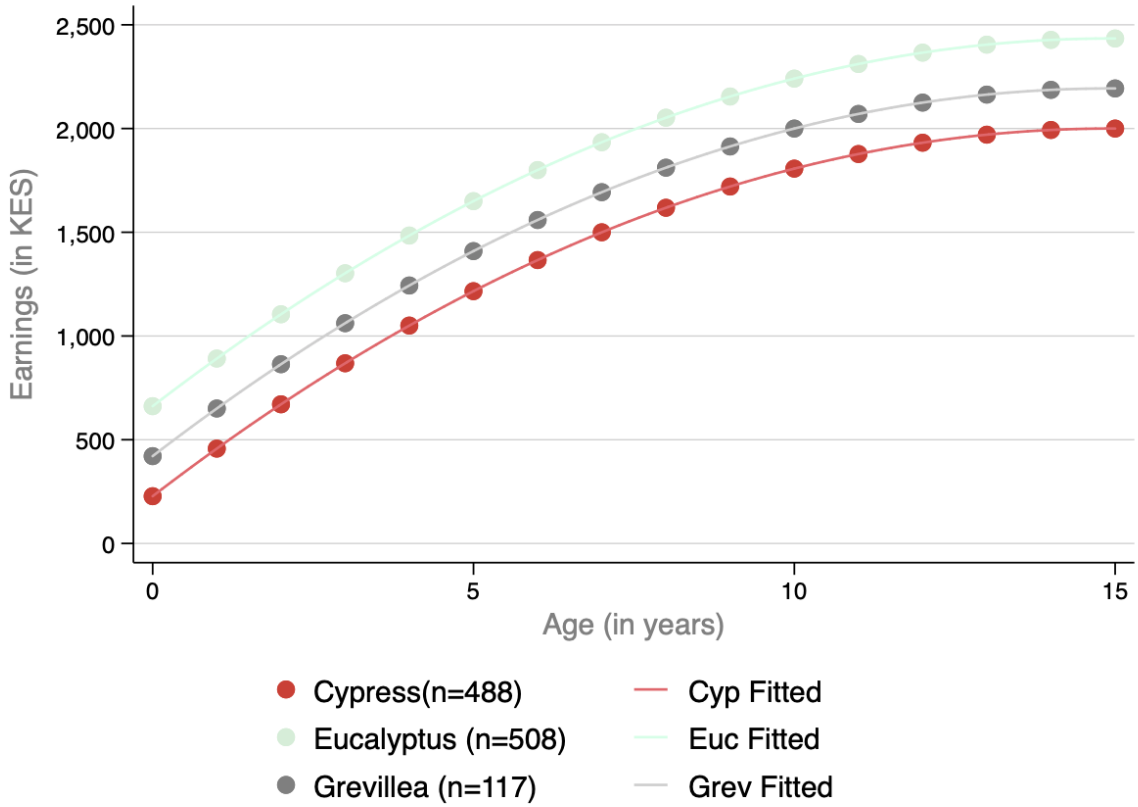
Table 6: Mean and median sales earnings by species in KES

	Cypress	Eucalyptus	Grevillea
Baseline			
Mean	2,049	2,234	2,121
95% CI	[1,865; 2,234]	[2,047; 2,422]	[1,430; 2,811]
Median	1,500	2,000	2,000
N	246	289	50
Midline			
Mean	1,948	2,312	2,100
95% CI	[1,900; 2,098]	[2,078; 2,546]	[1,631; 2,569]
Median	1,500	2,000	2,000
N	255	230	70

To explore the earnings by tree age for trees sold at baseline and midline, we build a quantile regression model with the median price per tree at each age. While this model is approximate, it provides us with viable prices for timber trees at each tree age. Further, the model follows similar trends to the WTP model, but with lower ranges. For example, in this model, grevillea tree earnings range from KES 421 for a newly planted tree to KES 2,193 for a 15-year-old tree[25].

[25] The modelled earnings can be found in Appendix 7.

Figure 9: Earnings by tree species



Overall, it is noteworthy that the intended prices for selling harvested trees are much higher than the earnings per tree recorded at baseline and midline.[26] One explanation might be that the farmers at endline overestimate future sales prices for their trees compared to prices they will actually be able to achieve.

5.4 Cost-Benefit Analysis

In this section, we explore the costs and benefits of the One Acre Fund Tree Program and build a Net Present Value (NPV) model to answer the research question on the present and future value of the program.

For this section we detail the caveats of each assumption taken to calculate either the costs or benefits that farmers can expect to receive from the program. We note that because of the limited scope of the endline survey, we did not capture detailed data on the time costs for planting and maintaining trees. We further note that for the benefit analysis, we use modelled data, which is approximate.

5.4.1 Costs

We start the discussion on the costs that farmers incur because of the Tree Program by analyzing whether there is a treatment effect on the land-use allocation, using baseline and midline data. We then look at the time-costs that farmers may incur to plant and maintain their

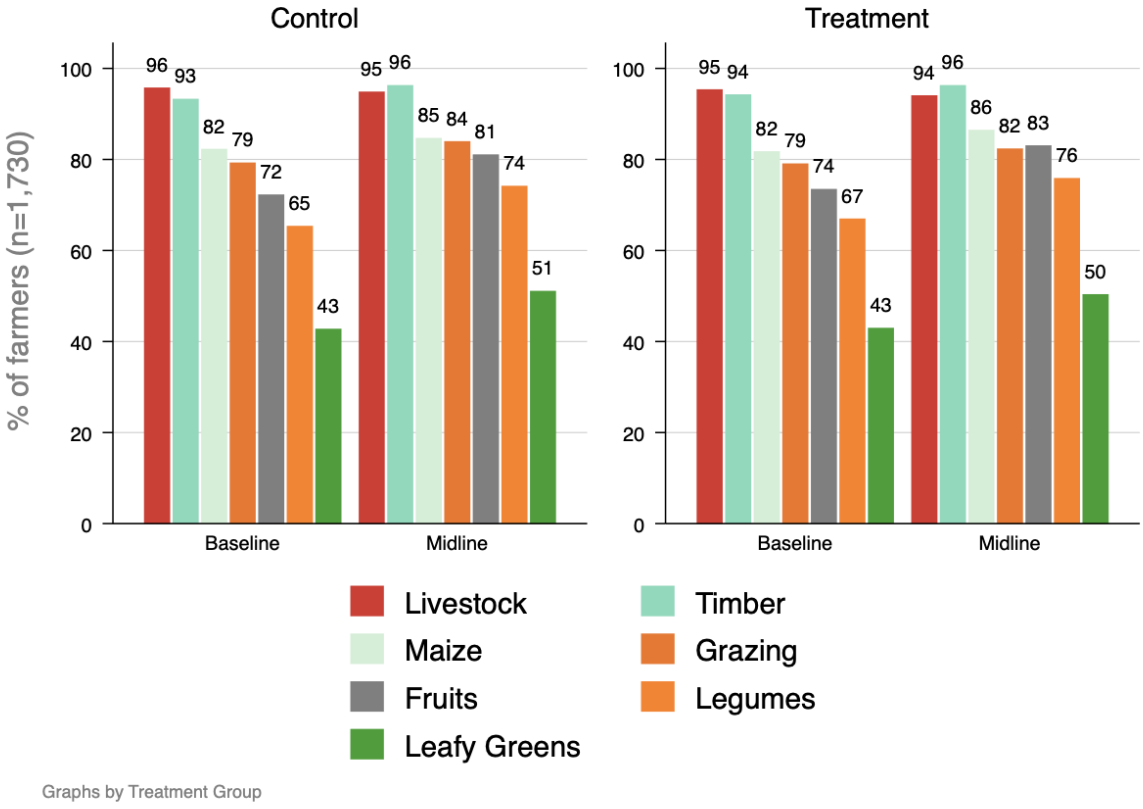
[26] As a robustness check we estimated mean earnings per tree by species for baseline and midline for the endline sample. The results do not change significantly.

additional grevillea trees using baseline, midline, and qualitative data. We finally quantify these costs for the sole purpose of developing our NPV model.

5.4.1.1 Land Use

We explore whether there are treatment effects on the land use of 1AF farmers. The ability of a farmer to plant grevillea trees as a long-term investment depends on the amount of land available for trees. If farmers displace other plants or livestock to grow grevillea trees, this would imply an opportunity cost as farmers would be able to grow less plants or hold less livestock for own consumption or sale. For this analysis, we group plants into the categories shown on Table 19[27] in Appendix 9 and include livestock and grazing land in the analysis.

Figure 10: Plant categories



We find no statistically significant treatment effect on whether a farmer had planted any type of plant, had grazing land, or had livestock on their farm (Figure 10), except for vegetables. For other plants and livestock, we also do not find a statistically significant treatment effect on the number of types of plants and Tropical Livestock Units that a farmer grew or owned. The results show that the program decreased the share of farmers who planted vegetables in the past 12 months by 4.8 percentage points, holding everything else equal, using a difference-in-difference model. This effect is significant at the 5% level.

[27] Additional plant categories comprise vegetables, roots and tubers, and cash crops. We exclude this from the graph because less than a quarter of farmers grew these plants at baseline and midline.

However, the effect is not significant on the number of different vegetable types a farmer planted.

Overall, we conclude that the farmers do not incur a major opportunity cost in terms of land-use because of the Tree Program. The treatment effect on a higher share of farmers planting grevillea and more grevillea trees being planted on the treatment farmers' land does not displace other types of plants or livestock, except possibly vegetables, and does not affect whether farmers have grazing land.

While the treatment effect might affect the area planted with each type of plant, qualitative insights suggest that this is not the case. Farmers and key informants argue that grevillea trees are excellent trees for intercropping and explain that grevillea trees are usually planted with other crops, including coffee, and provide shade to avoid drying.

5.4.1.2 Time Cost

Apart from the tree kit price charged by 1AF, we assume that there are no additional quantifiable monetary costs that occur to the farmer to grow the seeds and seedlings received by 1AF. Farmers in the trial districts, i.e., treatment farmers in our sample, were offered the tree kit for a total of KES 505. This price consisted of a bag with 10g of grevillea seeds, two bags for planting, 100 planting sockets, and tree fertilizer (priced together at KES 200), training for the tree kit (KES 200), loan interest (KES 130), transportation and quality assurance (KES 25). We exclude, the price for 50g of Sukuma wiki seeds (KES 90) and funeral insurance (KES 200) included in the tree kit price, as these are unrelated to the grevillea trees. In 2020, farmers in our study area were not able to purchase the tree kit to not affect the RCT.

The qualitative interviews suggest that a lot of time and care is required for planting and maintaining a grevillea tree. This ranges from selecting a suitable area to plant the tree, knowledge to establish a nursery and transplant to the farm, watering, and fencing to keep off predators. Water and good soil are mentioned as the key factors for tree seedlings to survive. Additionally, some materials needed for tree planting are challenging to access in the program areas. In two of the six treatment groups, farmers reported that the sand needed for soil mixing is not easily accessible. Additionally, in four of the eleven groups interviewed, farmers reported that accessing water to irrigate seeds and seedlings was difficult as well.

Box 5: Quotes on tree planting and maintenance

> *"The sand was a bit difficult to get and also water was a problem since this place is so dry and sunny."* (Farmer, treatment)
>
> *"The problem we experienced was getting the sand we travel far to buy it and one wheelbarrow is KES 150, then transport with the motorbike, so that was a challenge."* (Farmer, treatment)

We assume that treatment farmers incur time costs for i) attending training sessions from the Tree Program, ii) procuring the correct soil and water to plant the grevillea seeds, iii) planting the tree seeds, iv) socketing the germinated seedlings and establishing a nursery, v) choosing an area and transplanting the seedlings into the

ground, and vi) pruning the tree seedlings. We assume that the tree trainings, soil procurement, planting, socketing and nursery establishment, transplanting and pruning time costs are a one-off event. The watering of seeds should happen at least twice a day for a maximum of two months, before the seeds germinate.

To simplify the analysis, we value a day spent on planting and maintaining trees at the probability of a farmer having engaged in paid labor in the past 12 months at midline times the minimum wage for a general laborer in the rural areas of Kenya, namely KES 154[28]. For the 12 months preceding the midline, the probability of a farmer having engaged in paid labor is 42%, while the minimum wage for a general laborer in the rural areas of Kenya of KES 367[29].

We account for economies of scale when calculating time costs to maintain trees. For this, we use a logarithmic function that calculates the additional time that a farmer needs to spend for each additional tree that needs to be maintained. In practice, this translates to a smaller increase in time-cost units per farmer the larger the number of trees that need to be maintained.

5.4.2 Benefits

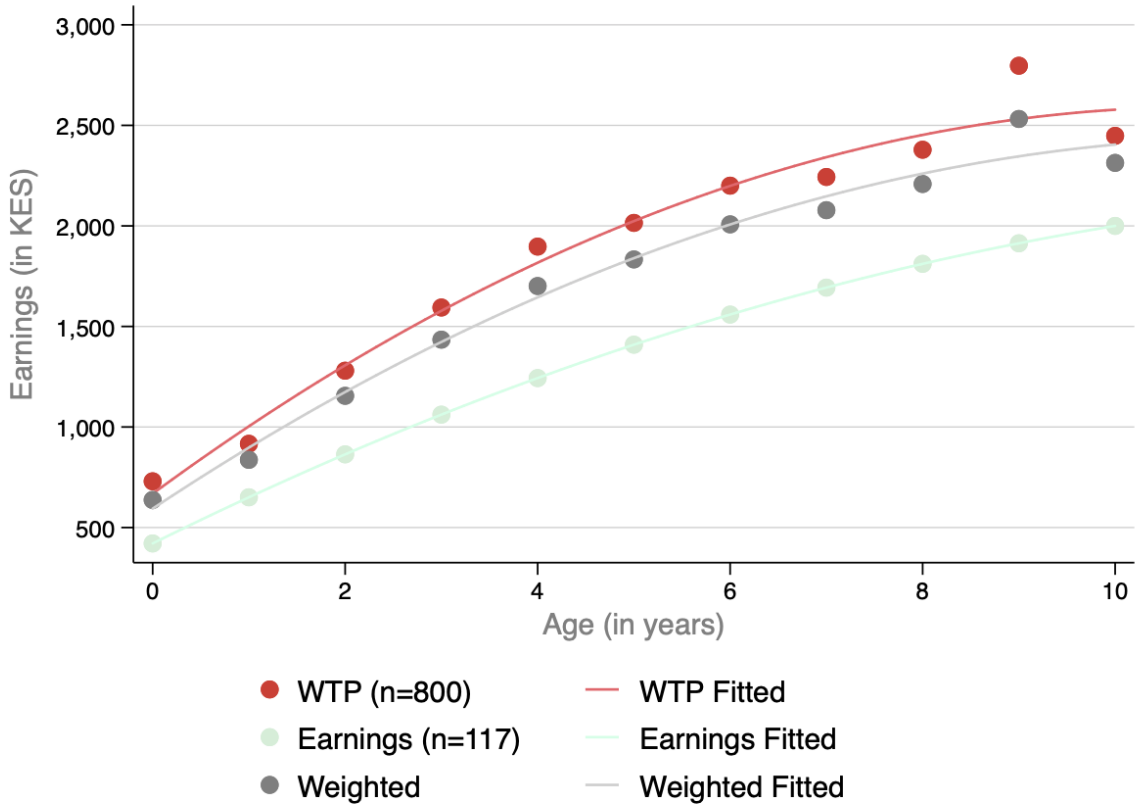
In order to quantify the monetary benefits of the Tree Program, we use the modelled WTP data from section 4.2 and the modelled earnings data from section 4.3[30] for grevillea trees. To simplify the analysis, we use data on WTP and earnings for trees that are up to 10 years old and assign WTP data a 70% weight and earnings data a 30% weight to account for the difference in number of observations and the fact that farmers use grevillea for self-consumption widely (Figure 11).

This quantification method internalizes self-consumption of grevillea trees. The WTP model considers that farmers do not necessarily sell all their trees and that not all tree usages imply harvesting a full tree. Nonetheless, farmers would still require wood from timber trees for firewood or for own construction if they did not have their own timber trees. Thus, the WTP model, while approximate, is able to cover valuation data that goes beyond capturing actual marketed prices and is more accurate than expected prices for harvesting trees.

Further, by using medians instead of means, and by removing extreme outliers from our estimations, we ensure that the valuation data follows a smooth distribution. Averaged data might be affected by outliers on both tails of the distribution and provide more dispersed data, and given the low number of observations, this might distort the valuation distributions.

[28] This estimation is a simplified version of the IDInsight methodology on estimating the opportunity cost of labor recommended to One Acre Fund. The recommended methodology is to estimate the average probability of a casual laborer getting hired on a given day, conditional on them seeking work, by the going wage rate.
[29] Kenyan Minimum Wage Law - 2018
[30] The tree trader survey contains limited data on grevillea pricing, given that few traders deal with grevillea trees. For this reason, the data is not used for this section.

Figure 11: Median benefit per year



Overall, we assume that farmers have a higher earning potential the longer they keep their trees (Table 7). The benefits from each year grow almost linearly between year 1 and year 5. However, after year 6, that difference is not marked anymore and the potential monetary benefits range from KES 2,008 to KES 2,532 in these years, using the weighted model.

Table 7: Median benefit per year

Tree Value (KES) / Age (Years)	WTP Model (n = 880)	Earnings Model (n=117)	Weighted Median
0	421	730	637
1	650	917	837
2	864	1,280	1,155
3	1,062	1,594	1,434
4	1,243	1,897	1,701
5	1,409	2,015	1,833
6	1,559	2,200	2,008
7	1,693	2,243	2,078
8	1,811	2,379	2,209
9	1,914	2,797	2,532
10	2,000	2,448	2,314

5.4.3 Net Present Value

This section presents the Net Present Value (NPV) for an *average* treatment farmer using the weighted *median* revenue model[31]. The model is based on the parameters specified above and is based on the following assumptions:

- The *average treatment effect* is **7.5 additional grevillea trees** planted by treatment farmers.
- Farmers harvest on *average* **60%** of their grevillea trees, when they are **7 years old**.
- Before harvesting the trees, farmers can realize **20% of the potential revenue** from a tree on a given year, **starting in year 3**[32]. The fraction of potential revenue for the trees that they do not harvest can be realized with a diminishing rate of 5% per year for up to 10 years.
- The tree kit cost is incurred only once in year zero. Farmers require **2 days** in year to plant and maintain their seeds to eventually plant seedlings on the ground, independent of the number of trees they eventually plant.
- Farmers require *at least* **1 day** per year to maintain their trees. They require additional time for each additional tree, but this follows a *logarithmic growth function*, where each additional tree brings a smaller increase in time for tree care.
- Farmers incur a daily cost of **KES 154**, which corresponds to 42% of the daily minimum wage for casual workers in rural Kenya.
- The *annualized* discount rate is 7.5**%**[33].
- The exchange rate between KES and USD is **0.0091**.

With these assumptions, we estimate that the NPV for an average farmer in a time frame of ten years is KES 12,007 or $109.26 (Figure 12). We note that our model is only approximate and is very sensitive to parameter specifications. Further, our model does not account for indirect benefits, such as an increase of productivity on other crops because of the additional shade provided by additional grevillea trees. We also do not include opportunity costs in terms of land use for farmers planting additional trees, based on the discussion form section 4.4.1.1.

[31] Please consult the NPV modeled annexed to this report for different NPV specifications.
[32] For example, by using branches for firewood or for sale without harvesting the tree.
[33] This discount rate is based on One Acre Fund's literature review and commonly used rate, and follows the methodology used in the World Bank's Handbook on Economic Analysis of Investment Operations and J-PAL's Cost-Effectiveness Analysis to Inform Policy in Developing Programs.

Figure 12: Net Present Value

Year	0	1	2	3	4	5	6	7	8	9	10	Total
Revenue												
Tree Revenue (Unsold U	KES 637	KES 837	KES 1,155	KES 1,434	KES 1,701	KES 1,833	KES 2,008	KES 2,078	KES 2,209	KES 2,532	KES 2,314	
Realized Revenue (Unsold Ur	0%	0%	0%	20%	19%	18%	17%	16%	15%	15%	14%	
# Trees Not Sold	7.5	7.5	7.5	7.5	7.5	7.5	7.5	3.0	3.0	3.0	3.0	
Tree Revenue (Sold Unit	KES 730	KES 917	KES 1,280	KES 1,594	KES 1,897	KES 2,015	KES 2,200	KES 2,243	KES 2,379	KES 2,797	KES 2,448	
# Trees Sold	0	0	0	0	0	0	0	4.5	0	0	0	
Total Revenue	KES 0	KES 0	KES 0	KES 2,151	KES 2,424	KES 2,481	KES 2,582	KES 11,109	KES 1,026	KES 1,117	KES 970	
Discount Rate	1.00	0.93	0.87	0.80	0.75	0.70	0.65	0.60	0.56	0.52	0.49	
Discounted Revenue (N	KES 0	KES 0	KES 0	KES 1,731	KES 1,815	KES 1,728	KES 1,673	KES 6,696	KES 575	KES 582	KES 470	**KES 15,272**
Costs												
Maintenance Cost (Day)	KES 308	KES 154	KES 154	KES 154	KES 154	KES 154	KES 154	KES 154	KES 154	KES 154	KES 154	
Tree Kit Cost (Unit)	KES 67	KES 0	KES 0	KES 0	KES 0	KES 0	KES 0	KES 0	KES 0	KES 0	KES 0	
# Trees Left	7.5	7.5	7.5	7.5	7.5	7.5	7.5	3.0	3.0	3.0	3.0	
Total Cost	KES 1,414	KES 289	KES 289	KES 289	KES 289	KES 289	KES 289	KES 228	KES 228	KES 228	KES 228	
Discount Rate	1.00	0.93	0.87	0.80	0.75	0.70	0.65	0.60	0.56	0.52	0.49	
Discounted Cost (NPV)	KES 1,414	KES 269	KES 250	KES 233	KES 216	KES 201	KES 187	KES 137	KES 128	KES 119	KES 110	**KES 3,265**
Income												
Total Income for Tree Pr	(KES 1,414)	(KES 289)	(KES 289)	KES 1,862	KES 2,135	KES 2,192	KES 2,293	KES 10,881	KES 798	KES 889	KES 742	KES 19,800
Discount Rate	1.00	0.93	0.87	0.80	0.75	0.70	0.65	0.60	0.56	0.52	0.49	
Discounted Income (NP	(KES 1,414)	(KES 269)	(KES 250)	KES 1,493	KES 1,593	KES 1,527	KES 1,486	KES 6,559	KES 447	KES 464	KES 360	**KES 12,007**
Discounted Income $ (N	$ (12.87)	$ (2.45)	$ (2.28)	$ 13.64	$ 14.55	$ 13.90	$ 13.52	$ 59.68	$ 4.07	$ 4.22	$ 3.28	**$ 109.26**

5.5 Farmers' Perception Towards Tree Planting

In this section, we look at the reasons for planting timber trees at both baseline and midline and use qualitative data to contextualize these findings. This section answers the research question on farmers' attitudes towards tree planting. While for the most part, we cannot attribute changes in attitudes to the Tree Program, we elaborate on each finding from a programmatic perspective.

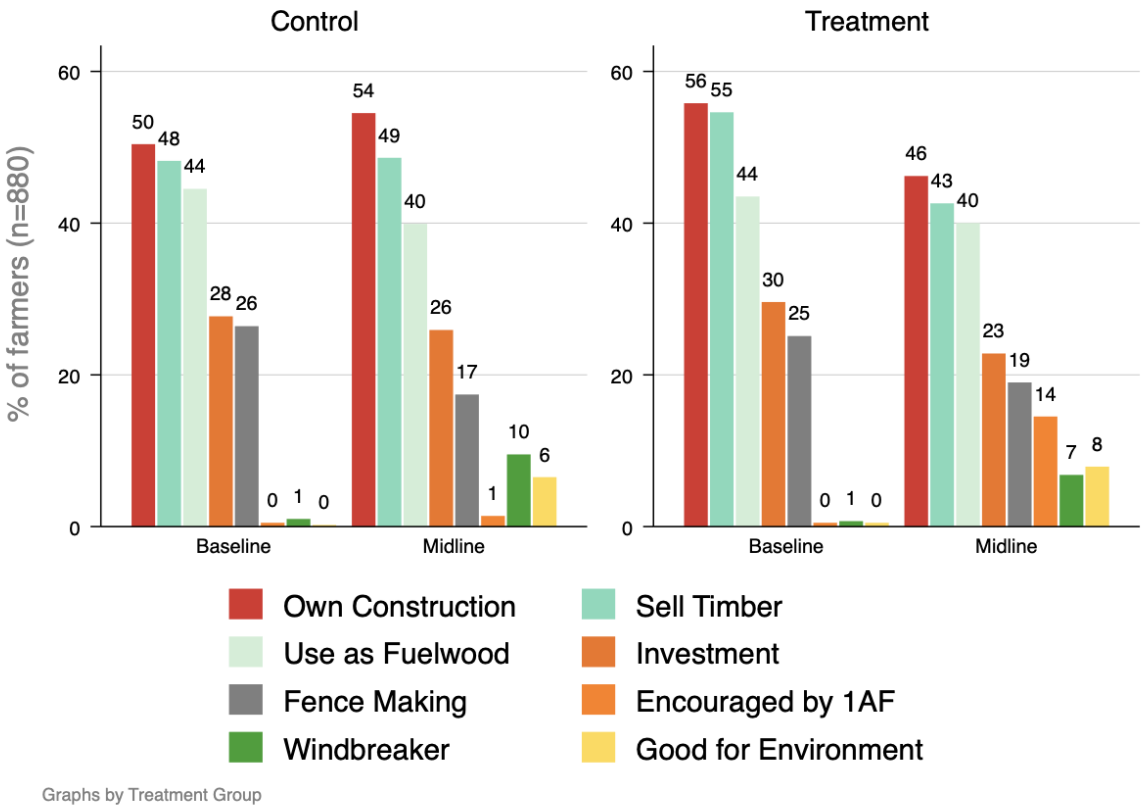
5.5.1 Reasons to Plant Timber Trees

At both baseline and midline, the three most mentioned reasons for planting timber were for own construction, to sell as timber, and to use as firewood (Figure 13)[34]. Other important reasons at baseline were as an investment and for fence making. A negligible proportion of farmers mentioned environmental reasons or to use trees as windbreakers at baseline. Further, less than 1% of farmers mentioned that they planted timber trees because of 1AF encouragement at baseline.

While we do not have enough observations to evaluate whether the treatment had a significant effect on the reasons why farmers planted timber trees, we observe an upwards trend in the proportion of farmers planting trees for environmental reasons and as windbreakers. We also observe this trend for planting because of 1AF encouragement.

[34] We note that only half of the midline sample planted timber in this time period and that the farmers who planted timber at baseline are not necessarily the same as those who planted at midline.

Figure 13: Reasons for planting timber trees



5.5.2 Qualitative perspectives

At baseline, the FGDs with farmers revealed that farmers did not necessarily see trees as an asset on the same level as land or livestock. Farmers viewed the uses of trees (firewood, construction, sale of timber) as important to their lives and farms but considered trees to take a long time to mature. Grevillea specifically was noted as a source for cattle fodder.

FGD participants at baseline planted trees mostly for timber use and firewood. The cost of buying timber influenced this decision. Additionally, farmers acknowledged the environmental advantages of tree planting, including improvement of air quality and prevention of degrading the local environment.

Box 6: Baseline perceptions on trees

"I have not sold trees, I have only planted a few trees, what could give me profit is the coffee I planted." (Farmer, baseline)

"For coffee, when the kilos are measured they are higher, unlike the indigenous trees I only cut them down to sell them." (Farmer, baseline)

"When you need to construct you have to buy timber and you feel robbed since timber is expensive. You will be motivated to plant trees so that your children don't need to buy timber for construction." (Farmer, baseline)

"We need pieces of firewood, the pieces of land have become too small and we cannot harvest firewood from someone's farm." (Farmer, baseline)

There is a variation in farmers' perceptions towards tree planting at endline compared to baseline where the majority of farmers did not see trees as very meaningful assets. In six (four treatment and two control) of eleven groups farmers mentioned that before the program, they did not view trees as important assets. Similarly, in three (two treatment and one control) of eleven groups, farmers mentioned that they were not aware of any trees that could be intercropped with other crops such as tea and coffee. The program provided the farmers with this knowledge.

In addition, 12 of 19 FOs reported that many farmers both in the control group and those not enrolled in the program were interested in tree planting. The change towards tree planting in control FGDs might be partially explained by control farmers attending the tree training. At midline, we found that a fifth (21%) of farmers in the control group had attended at least one tree taining session.

Box 7: Endline perceptions on trees

"The program did help because in the past I was not aware of trees that can be planted in the coffee farm." (Farmer, treatment)

"I learned that trees are important since we use them for firewood, can sell as timber, can use for fencing, and also can use for building a house." (Farmer, treatment)

"Previously, I did not see the importance of planting trees, but this training has made me see the importance and I will plant many trees for my use and sale." (Farmer, treatment)

"We also wanted to be given the tree seeds and do not understand why we were not given. Trees are important." (Farmer, control)

"Many farmers in the control group were interested in the tree kit and they asked questions. Some even attended training and I could not chase them away." (Field Officer)

"With the ban on logging in the forest, so many people are now interested in planting their own trees and this program is good for them especially those farmers that received the tree seeds. The problem is they did not germinate. If they germinated, a lot of people would have planted more trees because the seedlings would be available." (Field Officer)

When discussing tree species preference in similar future programs with FGD participants; grevillea, cypress, and fruit trees were mostly preferred, both in treatment and control groups (Table 8). Grevillea would provide fuelwood, cypress timber for construction and fruit trees food both for own consumption and sale.

While this finding seemingly contradicts the fact that grevillea trees are not widely commercialized and that the farmers' willingness to pay for grevillea is lowest amongst tree species, we hypothesize that farmers recognize the benefits of grevillea trees. The quantitative findings show that while the majority of grevillea owners use the trees for firewood, a non-negligible proportion of farmers also use grevillea trees for soil improvement, as shade for crops, animal fodder, and for environmental conservation. The qualitative findings additionally point towards farmers appreciating that grevillea trees can be intercropped with other food- and cash crops.

Table 8: Tree species preference

Tree Species	Frequency (out of 11)
Cypress	9
Grevillea	9
Fruit trees (avocado, orange, mango)	6
Eucalyptus	5
Wattle	3
Indigenous tree	2
Pine	1

6 Additional Findings

This section presents additional findings that do not directly correspond to the study's research questions set out at the beginning of this project. The section includes results from the endline FGDs and KIIs as well as additional empirical analysis on data collected at baseline, midline, and endline.

At endline, we conducted eleven FGDs (six in Kericho including the pilot and five in Uasin Gishu) and 19 KIIs (twelve in Kericho and seven in Uasin Gishu) in the study areas.

6.1 Process Evaluation

This section provides context and nuance to quantitative findings around the 1AF Tree Program from the midline survey. We look specifically at the Tree Program treatment uptake, detailing the experience of farmers and FOs around the distribution and quality of the tree kits and tree training. We then explore the farmers' and FOs opinions on the Tree Program and their preferences for future programs involving tree seeds and seedlings. Finally, we report additional outcomes from the qualitative interviews on the 1AF program in general.

6.1.1 Tree Kit

At midline, almost all (92%) of the treatment farmers reported that they received the tree kit. There was some variation on the specific elements from the tree kit that farmers received, but at least 89% of the treatment farmers reported receiving tree seeds, planting bags, tree sockets, or fertilizer for the trees.

All key informants from treatment areas were involved in the distribution of the grevillea tree kit.[35] The kits were distributed together with all other inputs and the FOs used the "Input Delivery Sheet" to distribute these inputs, noting that the system worked smoothly for the distribution.

Field Officers used multiple means of communication to ensure that farmers were aware of when to pick up their inputs. FOs used the group structures, called farmers, and sent them SMSs to disseminate the information. Additionally, some FOs visited farmers directly or sent reminders to them through group leaders, outside scheduled meetings.

[35] Two FOs from treatment groups reported that some farmers from the control group received tree kits through the JiT trial, where farmers could sign up to the 1AF program at the time of delivery. We had audited the JiT records at midline and found that only 1% of control farmers received tree kits through the initiative. This does not affect the results of this study.

Box 8: Quotes on input delivery

"We were using input delivery sheet (Ids) because it is the input delivery sheets which was showing us who is to receive and who is not supposed to receive (the tree kits)." (FO, treatment)

"*In my site through the Input delivery sheets (IDS) everyone was supposed to receive the tree kits. I had the list of their names written what inputs they will get."* (FO, treatment)

"I would visit them a week before, I give them the date and time of the delivery and the venue and then they would come that day of delivery of inputs… I would use word of mouth, SMS (sending messages) and phone calls and those who don't have phones I would visit them" (FO, treatment)

"We would call them via phone, we would send them messages through SMS, I would use the group leaders to notify the farmers or when we are in group meetings we would notify them (of when to deliver the inputs)" (FO, treatment)

6.1.2 Grevillea Seeds and Seedlings

Overall, over two thirds (69%) of treatment farmers planted the grevillea seeds in tree bags at midline. However, only a quarter (25%) of the treatment farmers planted germinated seedlings on the ground. This compares to germination rates of 55-79% according to the Kenya Forestry Research Institute and germination rates of 30-90% according to the World Agroforestry Center. The most common reasons for seedlings not being planted on the ground were that they died in the sockets, followed by lack of rain.

In the FGDs farmers stated that germination rates for the grevillea seeds of the tree kit were low. Even among farmers who reported following all the instructions from the tree trainings, germination rates were low, and they suspected that this was due to poor seed quality.

We note that the findings on low germination rates are expected by One Acre Fund based on their experience and the quality of the seeds available in the Kenyan market. Grevillea seeds are not sold commercially in Kenya, and the seeds acquired by One Acre Fund only come from a few sources and it is known that it is not of the highest quality. 1AF provides farmers with more three to four times the amount of seed needed for this reason. Further, germinating seeds depends on good quality inputs and farmers do not always use the correct soil mixture and fertilizers. Finally, seeds that are not planted right away may have lower chances of germinating in the future.

Box 9: Quotes on tree seeds germination

"When you see the seedlings, they are not that good, I think the seeds were not that good because the trees are not that good. Generally, in this area we don't lack rain you will not say it lacked rain." (Farmer, treatment)

"For me, I followed all the training that we were told, mixed the soil, sand and fertilizer. I watered but a few seeds germinated so I don't understand why. I transplanted about 5 seedlings." (Farmer, treatment)

Some FGD participants reported that they had not planted the seeds from the kit. The participants attributed this to lack of time and knowledge to plant the seeds. Other participants mentioned that they were discouraged after seeing their neighbors' seeds not germinate.

Box 10: Quotes on not planting the tree seeds

"Some farmers didn't plant the trees because of scarcity of water or shortage of rain. They said they did not plant the seeds because where they access water is far." (Field Officer)

"The seeds need water, and I don't have time to get the water since the water point is quite far. I may not plant them because all people here have said their seeds did not germinate." (Farmer, treatment)

"I have not planted my seeds yet because I gave up after seeing my neighbor's seeds did not germinate." (Farmer, treatment)

"For me I have not planted mine because I am busy and no time. Also, I did not attend training on how to plant the seeds because I was unwell. I will plant later but, in this area, we have a challenge with water because you travel a long distance to get the water." (Farmer, treatment)

6.1.3 Training Attendance

At midline, 62% of the treatment farmers reported having attended the tree trainings provided by 1AF. Overall, almost a third (63%) of the farmers in the treatment group who did not attend the tree training did not know about it. Additionally, a fifth (19%) of the farmers state not having had time to attend the tree training as a reason not to attend. Finally, we also find that over a fifth (21%) of the control farmers self-reported to have attended the tree training.

Although most of the FOs reported facilitating about four training sessions as part of the base package for treatment group, most FGD participants reported attending only one or two training sessions. Lack of time and previous knowledge in tree planting were some of the reasons cited by those who did not attend the trainings. Additionally, individual FOs mentioned that farmers did not take the tree trainings as seriously as other 1AF sessions or that attendance dropped as farmers received training booklets in the first session and were satisfied with that knowledge.

Some farmers who did not attend training reported asking neighbors or household members that attended the training about the topics that were taught. The FOs made efforts to reach out to farmers who did not attend trainings by visiting them at home or advising them on the

phone whenever they called for support.

Box 11: Quotes on reasons for not attending training

"A time like this during planting season most of them don't come or attend because they go to work as casual laborers. In such cases I would do a follow-up by meeting their group leaders if the farmers had missed that training but if the farmer have missed completely, I train the group leaders so that they can train them." (Field Officer)

"I did not attend any training because I knew how to plant the grevilia previously and I think these seeds we were given were not good." (Farmer, treatment)

"We were told that if you don't know how to plant in the seedbed you call the group leader to assist you, but I knew how to plant so I did not attend training." (Farmer, treatment)

"On that day I did not have time to attend but I inquired from my neighbor who had attended, and she told me about the training." (Farmer, treatment)

"I did not have time and since my mother attended, she came and told us about the training and that's how I got to learn about it." (Farmer, treatment)

"I did not attend any training, because when the training was being carried on, I was not feeling well." (Farmer, treatment)

"Because I understood how to plant trees and I did not want help from the group leader." (Farmer, treatment)

Instances of farmers who were not part of the tree program attending training were reported by 11/15 FOs from the treatment group. Nonetheless, the FOs allowed them to participate in the trainings since they could not force them out. This is in line with the midline data, where we found that 21% of the control farmers attended tree trainings[36].

Box 12: Quotes on farmers from the control group attending training

"I would not refuse to allow them in. If I am in a group, I would separate them. If approached by them, I would listen and if they asked me about the program, I would not refuse to explain because I want them to get help also." (Field Officer)

"Most of them came to gain experience and knowledge. We accepted them into the training sessions." (Field Officer)

6.1.4 Understanding of Tree Planting Best Practices

At midline, we found a positive and statistically significant treatment effect on the number of tree planting knowledge questions that the farmers answer correctly. On individual practices, there was a positive and statistically significant treatment effect for the knowledge on using the correct soil for planting tree seeds. We also found that farmers who self-reported attendance to tree training tend to have better knowledge of tree planting best practices compared to farmers who did not attend the training. A higher proportion of farmers

[36] Contamination was dealt with at midline by estimating the local average treatment effect (LATE), which measured the average program effect on fully compliant farmers, considering contamination in the control sample.

that report attending the training know the correct soil for planting, the time they should wait for a grevillea seed to germinate, how often they should water grevillea seeds – best practices to maximize seed survival.

The baseline FGDs indicated that there was a need for training on tree planting and care. Farmers were more concerned about the skills needed to plant trees than about the time it takes someone to do the different tasks. Farmers were especially interested in learning about watering tree seedlings during the dry season, fencing seedlings to keep animals away and the procedure to transplant seedlings into the ground when they are ready.

There is a change in farmers' understanding of tree planting best practices at endline compared to baseline where a majority of 1AF farmers stated a need in both tree planting and care. Some of the farmers mentioned that before the training, they did not know the materials required and the process of tree planting. Most of those who attended the training were able to explain the process of growing grevillea trees from seeds. Similarly, KII participants noted that the training was very useful and covered knowledge gaps among farmers when it comes to planting not only grevillea trees but other trees as well.

Box 13: Quotes on understanding best practices

"I used to just prepare a seedbed and plant my tree seeds but since I attended the training, I learned how to mix sand and manure." (Farmer, treatment)

"It was good training because we did not know that the soil is mixed with manure so that is what we learned, and we are grateful." (Farmer, treatment)

When the Key Informants were asked about the most difficult topics to implement, 54% mentioned that no topics were difficult. For those who mentioned some topics were difficult, the common challenges were soil mixing, socketing, and transplanting.

Box 14: Quotes on difficult topics to implement

"The topic on socketing. This is because most farmers are used to planting seeds directly into the shamba so trying to change this was difficult." (Field Officer)

"Some of the farmers struggled with the tree transplanting topic. The timeline of when to transplant was a challenge to them." (Field Officer)

"The topic concerning the mixing of soil to be used for planting of the seeds." (Farmer, treatment)

"No, because we had been given booklets and there were trainings where we trained the farmers using those booklets and the farmers had the right to ask questions in case they did not understand a topic. Also, we were using demonstrations when training." (Field Officer)

6.1.5 Program Preference

Regarding preference between tree kits and seedlings, there were mixed reactions, though the majority preferred seedlings. Generally, farmers argued that seedlings were easier to plant and had higher chances at surviving than seeds, especially if these do not germinate. Participants who preferred seeds were largely from the control groups. The

arguments in favor noted that seeds are less expensive and that learning how to plant seeds is valuable knowledge. Overall, seedlings won by consensus in six groups (including the pilot FGD), seeds in one, and in four groups the farmers were divided between the two.

Box 15: Quotes on program preference

"Seedlings because it is ready to plant, and I will plant during rainy season unlike seeds which I have to take more time waiting." (Farmer, treatment)

"I would like seedling since the last time I took the seeds it did not germinate so I would prefer seedlings because I know I am just going to plant it." (Farmer, treatment)

"I like the seeds because it is less expensive compared to seedling. It is better because I will have many seeds compared to buying a specific number of seedlings and also learn how to plant." (Farmer, control)

"Farmers like seedlings more. This is because it has reduced labor requirements; has a high germination rate and also a farmer can easily take care of the seedlings as compared to the tree seeds." (Field Officer)

FOs were also in favor of seedlings rather than tree kits. The main argument was that seedlings are easier for farmers to plant and had higher survival rates. For the FOs who were in favor of seeds the main arguments were that farmers learn new skills by planting seeds and that with high germination rates they can make income from selling excess seedlings. Overall, 12 FOs were in favor of distributing seedlings and seven were in favor of the tree kits.

6.1.6 Thoughts on the 1AF Program

Generally, the participants agreed that the 1AF program has impacted them greatly. Through the provision of quality inputs and trainings farmers have improved their knowledge of farming resulting in increased food security. Farm inputs purchased by participants since joining the program varied. Though the core inputs package was similar for everyone, the add-on products depended on farmers' interest. Some participants had received solar, iron sheets, etc.

Box 16: Quotes on feedback on 1AF program

Since I joined 1AF, I have seen that I have improved in my farming since I have plenty of food so my experience with 1AF has been great. Also, most of 1AF products are of high quality, i.e., quality seeds, quality training." (Farmer, treatment)

"One thing that has made me happy working for 1AF is seeing farmers who were having food challenges now having plenty because of 1AF projects. As for me, working for 1AF has led to the improvement of my living standards." (Field Officer)

"1AF has been great to me, I have built a house using iron sheets that I got from 1AF so I appreciate 1AF and I don't think I can leave 1AF." (Farmer, control)

Provision of quality products (9/19), giving inputs on loans (9/19) and introduction of new products (4/19) were noted as success factors in program implementation. Other factors include timely delivery of inputs (2/19), introduction of Dukas (shops) closer to the

farmer (2/19) and the new policy on loan defaults where an individual is held accountable and not the whole group (2/19).

However, less than half (48%) of the farmers at midline renewed their 1AF contract. More farmers in the treatment group (50%) renewed their contract compared to farmers in the control group (45%). This difference is statistically significant at the 1% level. Additionally, farmers in Uasin Gishu (64%) were significantly more likely (at the 1% level) to renew their contracts compared to farmers in Kericho (36%). Out of the farmers who did not renew their contract at midline, 29% report that their loan group defaulted and therefore they were not allowed to join again[37], 15% stated that they had financial constraints were not able to raise enough funds to pay the sign-up fee, 8% stated that they were unhappy with a 1AF staff member (especially around debt collection, and 6% stated that they were either not aware or were too late to register for the 1AF program in 2020.

We note that the high rate of farmers reporting that their groups defaulted might be related to the unusual high rains that occurred in 2019, which may have spoilt some of their crops. According to satellite data, the study area experiences above average rainfall in 2019, especially due to uncharacteristically high rainfall in the long rainy season, paired with lower than usual rains in the traditionally dry season.

Moreover, farmers voiced their interest in obtaining new products on credit, as shown in Table 9.

Table 9: Interest in new products

New Product	Frequency (out of 19)
Water tanks	8
Wire mesh for poultry	4
Poultry	2
Television sets	2
Solar pumps	1
Generator	1
Watering cans	1

Additional suggestions from the FOs include transitioning towards a digital enrollment system for farmers joining the 1AF program, offering continuous enrollment throughout the year for interested farmers, and conducting training before distributing inputs.

6.2 Seedling Program

In addition to the main qualitative component of the endline, we held four KIIs (with two Nursery Managers and two Tree Field Managers) in the areas where 1AF is piloting a seedling program. We briefly discuss the findings from these discussions below.

[37] **Table 14** in Appendix 5 shows that additional significant determinants to whether farmers renewed their contracts include the TLU index, whether farmers had fruit plants at midline, and whether farmers sell food crops as an income generating activity.

Seedlings that are doing well at the nursery are most preferred by farmers regardless of their species, according to Marketing Officers and Tree Field Managers. Among the four species (grevillea, cypress, eucalyptus, and pine) in the tree nurseries, grevillea is most preferred as it grows faster than the other species. This results in a shortage of grevillea seedlings.

Box 17: Quote on tree species preference

"Farmers come to pick seedlings that they see doing well at the nursery hence they will all pick a certain species which in most cases is grevillea since it has grown well at the nursery as compared to species such as cypress which grows slowly. You will therefore find a shortage of grevillea seedlings at the nursery." (Marketing Officer)

Regarding preference between tree kit and seedlings, Marketing Officers were in favor of distributing tree kits, while Tree Field Managers were in favor of seedlings. For the former, the main advantage was that tree kits are easier to transport and distribute compared to seedlings while for the latter, seedlings have reduced labor requirements and high germination rates.

Box 18: Quotes on program preference in seedling pilot program areas

"I think tree kits is the best option because with the kits the farmers are able to get it near their homes but for seedlings, they have to travel to the nursery to get the seedlings which can be a challenge." (Marketing Officer)

"Tree seedlings are the best way to go. I have been a FO and TFM and I can assure you that if you get 2-3 farmers and ask them about tree kits, they received last year they would show you the whole package since once they are given, they end up just keeping them in their homes." (Tree Field Manager)

7 Key Findings

The main findings from this endline report correspond to five main research questions around i) timber tree uses, ii) demand and pricing of trees, iii) attitudes towards tree planting, iv) the cost-benefit-, and v) the financial value of the Tree Program. Other main findings correspond to the process evaluation of the Tree Program.

First, we find that the most important uses for timber trees vary among species, with firewood being ranked as the most important use for grevillea trees. Overall, 95% of the farmers use grevillea as firewood (either for own consumption or to sell), while three fifths (59%) use the trees as timber for sale, and around half (52%) use grevillea for construction of either buildings or furniture.

The data indicates that as grevillea trees mature, their use case changes. Younger trees are used for firewood and older trees are used for selling timber or for construction. Participants in the qualitative discussions noted that grevillea wood dries fast and is suitable for firewood. Additionally, while wood from grevillea trees can be used to build temporary structures, its timber quality is deemed inferior to that of cypress for construction.

Second, we find that farmers value eucalyptus and cypress trees higher than grevillea, using a willingness to pay (WTP) approach. When we model the value of a specific tree for a given age and considering all use cases, we find that the valuation for eucalyptus and cypress is almost identical, ranging from KES 1,400 to KES 3,430, while the valuation for grevillea is lower. Grevillea values range from KES 730 to KES 2,800 and peak when the trees are 9 years old.

Further, the willingness to pay is similar for trees used for construction and selling as timber, but lower for firewood. The exception is for cypress, which has a higher valuation when it is intended to be sold as timber compared to being used for construction.

Moreover, we find that there is high demand for timber trees obtained directly from the source and for cypress trees. Three fifths (60%) of the tree traders interviewed source their trees directly from farmers, commercial tree planters, or plantations. Most tree traders (79%) buy cypress trees, while only a fifth (19%) buy grevillea trees. Cypress is also preferred by most of the end clients of the tree traders.

Additionally, the data indicates that the farmers' demand for timber trees is not saturated. Almost all (95%) of the farmers interviewed at endline reported that they intend to plant more trees, with two thirds (62% and 63%, respectively) indicating that they intend to plant cypress and grevillea trees.

In terms of supply, around two thirds of farmers that owned cypress, grevillea, and eucalyptus intended to eventually harvest whole tree. Farmers would on average harvest 60-70% of their timber trees and they would do so when the trees are between seven and nine years old.

Third, we observe an upwards trend on the proportion of farmers that plant timber trees for environmental reasons and find that treatment farmers state that the Tree Program taught them about the importance of growing trees. The qualitative interviews show that treatment farmers gathered a deeper understanding of the benefits of growing timber trees and learned about intercropping grevillea in their farms.

Fourth, we find that the Tree Program does not disrupt land-use in general and benefits farmers through additional availability of grevillea trees and their byproducts as firewood and timber for own construction or sale. Further, we argue that farmers do not incur in additional monetary costs beyond the price of the tree kit (KES 505) and that time costs they incur are out-weighed by the benefits from the additional grevillea trees. Finally, we argue that financial benefits from the program need to account for the non-monetary value of farmers growing and consuming additional grevillea trees attained through the Tree Program.

Fifth, we find that regardless of model specifications, the Tree Program leads to a positive Net Present Value (NPV) in a 10-year horizon for treatment farmers. For the average farmer the NPV is KES 16,793. The model accounts for the fact that not all trees will be sold for cash and that farmers benefit from the trees while they are planted on their land. The model also considers land-use and time-use patterns, but does not account for potential indirect benefits.

The process evaluation showed that the Tree Program implementation went smoothly in terms of input delivery and that farmers learned about tree planting best practices, especially on soil-mixing. This is corroborated with the midline results, where we found that almost all (92%) of the treatment farmers received the tree kits and that the treatment had a significant and positive effect on the knowledge of tree planting and maintenance best practices and specifically on which soil to use to plant timber trees.

However, most farmers reported attending one or two Tree Program trainings from four delivered by Field Officers. At midline, 62% of the farmers reported attending the training and most farmers that did not attend reported that they did not know about the training taking place. We note that some trainings might not have taken place because the long rains came late in 2019.

Additionally, both farmers and Field Officers explained that the germination rates for the grevillea seeds of the tree kit were low. While over two thirds (69%) of farmers planted their seeds, only a quarter (25%) managed to plant germinated seeds on the ground.

Overall, while the input delivery went smoothly, the relatively low training attendance- and seed germination rates reveal that there is potential for the Tree Program to create additional impact. Future programs focusing on these areas can increase the impact in terms of the percentage of farmers that plant new grevillea trees and on the number of trees planted.

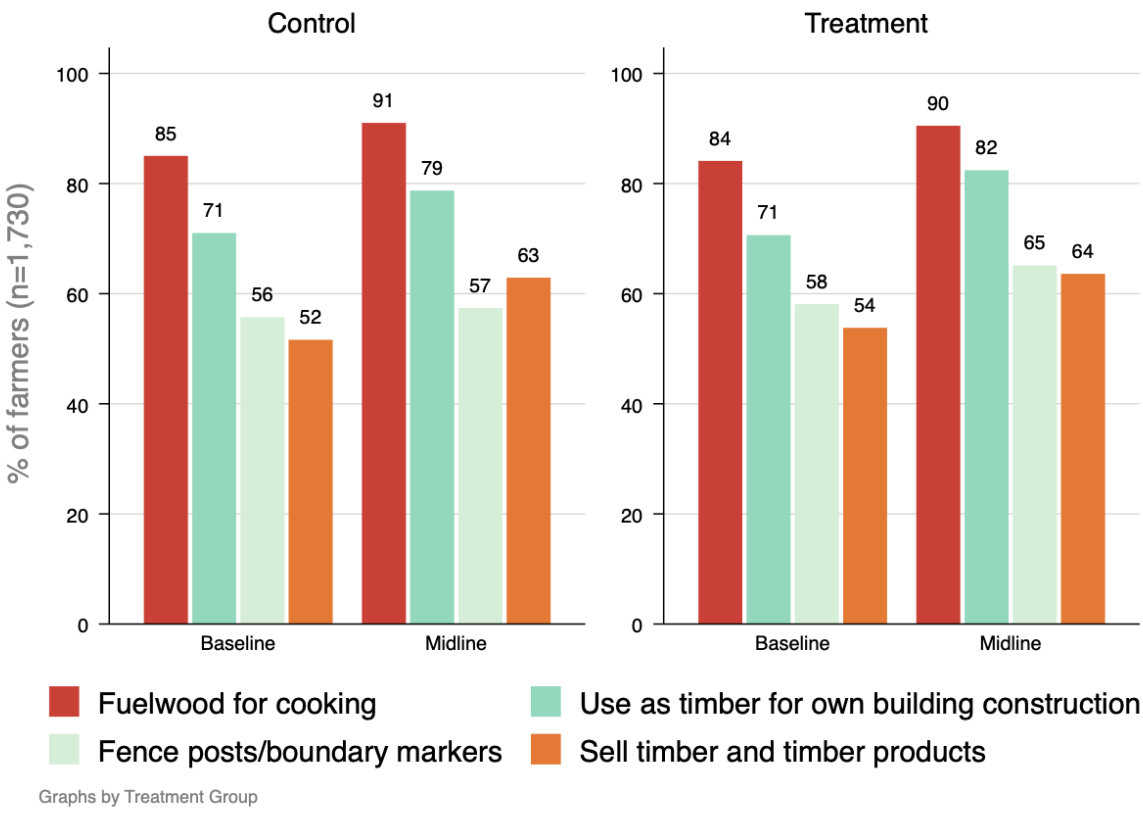
Finally, when asked about their preference for future programs, offering tree seedlings rather than tree seeds won by consensus in most FGDs and the majority of the FOs also chose a tree seedling program. Generally, farmers argued that seedlings were easier to plant and had higher chances at surviving than seeds, especially if these do not germinate**.** Similarly, for the FOs, the main argument was that seedlings are easier for farmers to plant and had higher survival.

Appendices

Appendix 1: Tree Uses at Baseline and Midline

Both at baseline and midline, the most common use for trees grown on the farmers' land was fuelwood for cooking (Figure 14).[38] This holds true when considering the control and treatment group farmers individually and when separating the sample by county (Kericho and Uasin Gishu). At both points in time, the second most named use for trees was for *own building construction*. The third and fourth most common uses were *fence posts/boundary markers* and *sell timber and timber products* at baseline and midline, respectively. This information is not directly comparable to endline as the uses were asked for all trees, and not timber trees specifically.

Figure 14: Four most common tree uses – Baseline and midline



At both baseline and midline, the most common fuel source for respondents was gathered firewood (79% of farmers at midline). Farmers who use gathered fuelwood as their main fuel source at midline, report spending on average 6 hours a week gathering fuelwood and 81% state that the nearest source is trees on their own farm. The second most common fuel source at both time points is purchased fuelwood, used by 18% of the sample.

[38] Farmers were asked about all the uses they have for trees grown on their land, including previous, current and planned future uses, but not including trees or tree products sourced off-farm.

Farmers who use purchased fuelwood as their main source, spent on average KES 278 per week on fuelwood at baseline, and KES 252 at midline. The median farmer spends KES 200 at both points in time.

We explore whether there are underlying characteristics associated with using purchased or gathered firewood as the main source for cooking fuel. For this analysis, we combine baseline and midline data. We run two panel logit regression models with varying dependent variables:

1) Using gathered fuelwood as the main source
2) Using purchased fuelwood as the main source.

We include demographic and socio-economic characteristics as the covariates to understand the association between explanatory variables and the outcome of interest. We look at the farmer's county of residence, age, gender, education level, household size (number of household members), Tropical Livestock Unit (TLU)[39] index, self-reported land size and two

39 Tropical Livestock Units are livestock numbers converted into a common unit based on the regional average weight of the livestock type. See

Appendix 7: WTP and Earnings Models

Table 17: WTP model valuation

Tree Value (KES) / Age (Years)	Grevillea	Eucalyptus	Cypress
0	730	1,400	1,438
1	917	1,738	1,710
2	1,280	2,023	2,120
3	1,594	2,327	2,355
4	1,897	2,550	2,660
5	2,015	2,915	2,845
6	2,200	2,916	2,883
7	2,243	3,081	3,118
8	2,379	3,356	3,356
9	2,797	3,323	3,187
10	2,448	3,221	3,530
No. of observations	**1,028**	**1,014**	**800**

Table 18: Earnings model valuation

Tree Value (KES) / Age (Years)	Grevillea	Eucalyptus	Cypress
0	421	662	228
1	650	891	457

binary variables indicating whether the household at baseline had more than 50 timber trees or more than 100 trees (all tree species), respectively. We also control for whether the farmer is in the treatment group and the year of data collection.

The results show that having more than 100 trees at baseline and owning more livestock are positively and significantly correlated with gathering fuelwood and negatively and significantly correlated with purchasing firewood (Table 10). We find the opposite for self-reported land size, but the magnitude of this effect is small. In addition, we see that households in Uasin Gishu are more likely to use purchased fuelwood, and less likely to use gathered fuelwood compared to households in Kericho. This is in line with our findings on socio-economic characteristics of households in the two counties. Farmers in Uasin Gishu own larger farms, have higher educational attainment and engage in more income-generating activities.

Table 10: Determinants of firewood as main cooking fuel

	Coefficient (Std. Error)	
	(1) Gathered fuelwood	**(2) Purchased fuelwood**
Treatment	0.02 (0.01)	-0.01 (0.01)
Year (2020)	0.04*** (0.01)	-0.03*** (0.01)
Uasin Gishu	-0.05*** (0.02)	0.03** (0.01)
Respondent Age	0.00 (0.00)	-0.00 (0.00)

2	864	1,105	671
3	1,062	1,302	868
4	1,243	1,484	1,050
5	1,409	1,650	1,216
6	1,559	1,800	1,366
7	1,693	1,934	1,500
8	1,811	2,052	1,618
9	1,914	2,154	1,720
10	2,000	2,241	1,807
11	2,070	2,311	1,877
12	2,125	2,366	1,932
13	2,164	2,404	1,970
14	2,186	2,427	1,993
15	2,193	2,434	2,000
No. of observations	**488**	**508**	**117**

Appendix 8 for TLU conversion rates.

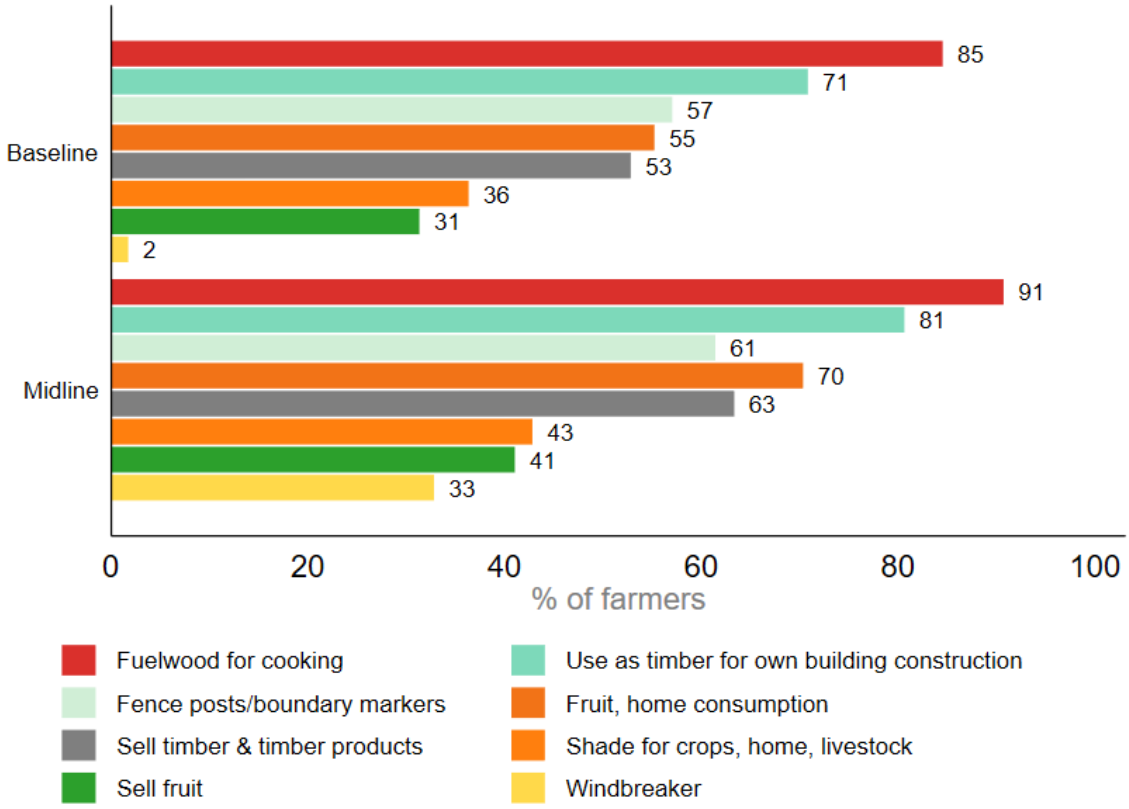
Respondent Age Squared	0.00 (0.00)	-0.00 (0.00)
Respondent Female	-0.02 (0.01)	0.01 (0.01)
Household Members	0.00 (0.00)	0.00 (0.00)
TLU Index	0.02*** (0.00)	-0.02*** (0.00)
Completed Primary Education	0.02 (0.02)	-0.02 (0.01)
Self-reported Land Size	-0.00** (0.00)	0.00** (0.00)
More than 50 Timber Trees at Baseline	-0.01 (0.02)	0.01 (0.02)
More than 100 Trees at Baseline	0.05** (0.02)	-0.04** (0.02)
No. of observations	**3,437**	**3,437**

In addition to firewood for own consumption, seven other uses were named by more than 30% of the farmers at baseline and midline for timber trees:

- Use as timber for own building construction
- Fruit (home consumption)
- Fence posts / boundary markers
- Sell timber & timber products
- Shade for crops, home, livestock
- Sell fruit
- Windbreaker

Between baseline and midline, there were only limited changes (see **Figure 15**).

Figure 15: Change of important uses over time

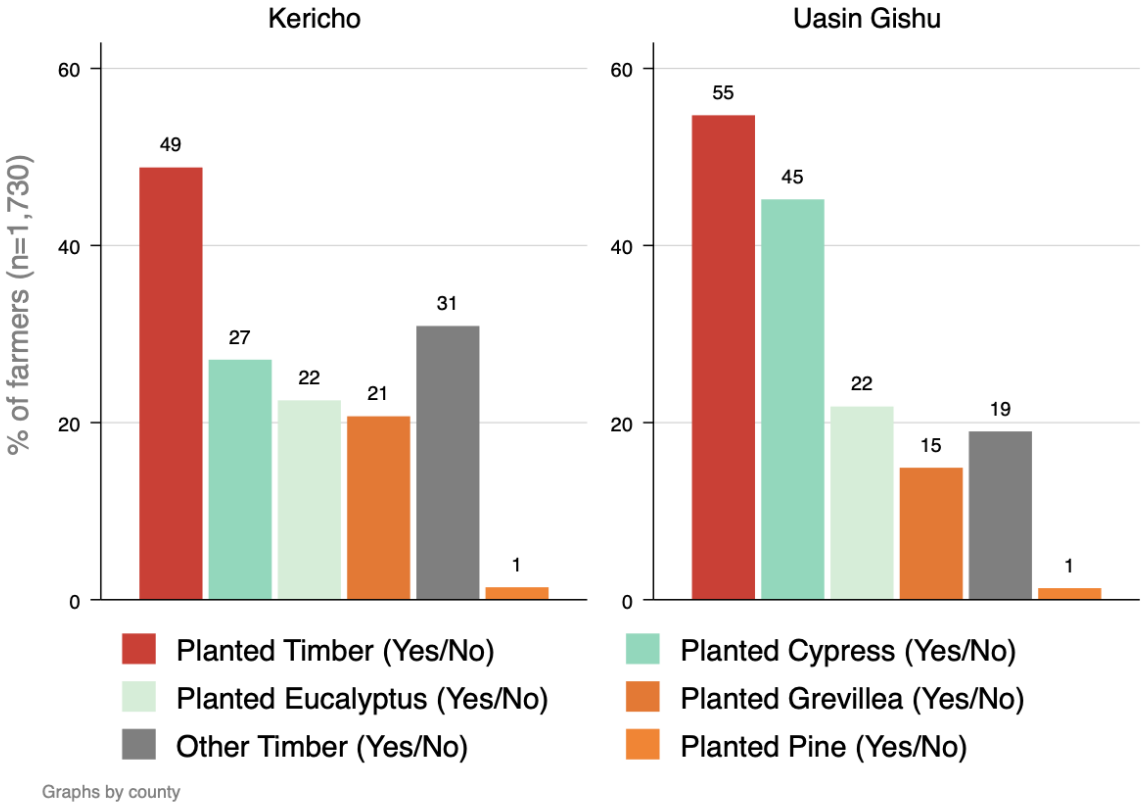


Appendix 2: Tree Ownership Midline

Table 11: Timber tree ownership at midline

Variable	Kericho (n=1,017)	Uasin Gishu (n=713)	All (n=1,730)	P-Value
Timber (Y/N)* **	95%	98%	96%	0.000
Cypress (Y/N)* **	74%	94%	83%	0.000
Eucalyptus (Y/N)* **	73%	78%	75%	0.007
Grevillea (Y/N)* **	65%	45%	57%	0.000
Other Timber (Y/N)* **	32%	20%	27%	0.000
Pine (Y/N)*	11%	14%	12%	0.057

Figure 16: Timber tree planting at midline by county



Appendix 3: Tree Uses at Endline

Table 12: Tree uses by species indicated by farmers at endline

Tree use	Pine	Grev.	Young grev.	Euc.	Cyp.	Other
Sell as timber	44%	58%	57%	**75%**	79%	10%
Sell branches	2%	7%	4%	8%	3%	0%
Use as timber for own building construction	33%	46%	49%	68%	**80%**	26%
Use as timber to make furniture	8%	14%	11%	21%	22%	7%
Sell as firewood	14%	17%	15%	24%	7%	4%
Firewood for own consumption	**68%**	**91%**	**80%**	61%	42%	73%
Make charcoal for sale	0%	1%	0%	2%	0%	10%
Make charcoal for own consumption	2%	2%	0%	2%	0%	22%
Make poles for climbing plants	2%	0%	0%	0%	1%	1%
Make fence posts	7%	3%	0%	**28%**	23%	8%
Animal fodder	0%	16%	12%	0%	0%	0%
Shade for crops, home, livestock	0%	17%	15%	4%	4%	13%
Windbreaker	4%	6%	11%	1%	4%	3%
Attract heavy rainfall, prevent flooding	6%	2%	0%	0%	0%	5%
Aesthetic purposes	9%	3%	5%	1%	2%	12%
Soil improvement/fertility, control erosion	0%	**26%**	18%	1%	1%	3%
Environmental conservation/air purification	7%	11%	5%	5%	11%	7%
Herbs/medicine	-	-	-	-	0%	10%
Source of seeds or seedlings	-	-	-	-	0%	-
Other	7%	1%	-	0%	1%	4%
No. of observations	**32**	**174**	**55**	**213**	**237**	**69**

Appendix 4: Other Timber Tree Species

Table 13: Other timber tree species

Other timber tree species	N	% of farmers
Acacia	5	7%
African Satinwood/White African Mahogany (Sagowaita)	2	3%
Ararwet	1	1%
Black Plum/Java Plum (Mzambarau, Mulkelwet, Lamaiyat)	4	6%
Bottle Brush	1	1%
Broad Leafed Croton (Tebesuet, Reberwet, Tebesuet)	33	48%
Cape Fig/ Broom Cluster Fig (Mkuyu, Mogoiwet, Mukuyu)	1	1%
Cedar	3	4%
Cider/African Juniper (Tarakwet, Perekeet, Tarakwet, Turkwet, Mutarakwa)	1	1%
Cordia Africana	4	6%
Croton (Masineitet, Mukinduri)	2	3%
Dog Plum/Cape Ash (Araruet, Teldet)	1	1%
Euclea Divinorum	3	4%
European Ash (Morombit)	3	4%
Jacaranda	1	1%
Kuriot	1	1%
Lamaywet	1	1%
Markhamia (Mobisarwet, Siala, Mobet)	3	4%
Mitandege	1	1%
Motomoshieet	1	1%
Nandi Flame (Sebetaiyet, Sebetaiyet)	1	1%
Natal Fig	1	1%
Natal Rhus	3	4%
Neem Tree (Muarubaini)	1	1%
Ochna Ovata	1	1%
Olive Tree (Mutamaiyo, Emitiot, Emidit/Yemit, Mutamaiyo)	6	9%
Peanut Butter Cassia (Senetiet, Senetwet, Senetiet, Senetwet)	2	3%
Pine (Cheesuumeyoon/ Chesarur-Msonobari)[40]	1	1%
Red Stinkwood/The African Cherry (Kiburabura, Mkongachuma, Arareut, Tenduet, Tendwet, Muiri)	12	17%
Red Thorn (Chebitet, Chepitet/Kerichsaru, Kaimetiet, Njebitet)	2	3%
Sodom Apple	1	1%
Tulaa	1	1%

[40] The farmer who mentioned pine as “other” also mentioned another tree species. Therefore, data was collected for both combined and the answers for pine cannot be extracted.

Wattle Tree	9	13%
White Iron Wood/Small Fruited Teclea (Koriot, Keriondet)	1	1%
Wild Elder Tree (Chorua)	1	1%
Wild Medlar/Spanish Tamarind (Mviru, Kimolonik, Kimolwet, Muviru)	9	13%

Appendix 5: Contract Renewal

Table 14: Determinants of renewing the 1AF contract at midline

	Coefficient (Std. Error)
Treatment	0.066*** (0.021)
County (Uasin Gishu)	0.250*** (0.021)
Respondent Age	0.004 (0.005)
Respondent Age Squared	-0.000 (0.000)
Respondent Female	0.031 (0.023)
Completed Primary Education	0.036 (0.027)
Household Members	-0.001 (0.005)
# Income Activities	-0.011 (0.014)
TLU Index	0.018*** (0.007)
Self-reported Land Size	-0.000 (0.000)
Planted Maize	0.032 (0.032)
Planted Cash Crops	-0.020 (0.027)
Planted Fruit	-0.046 (0.029)
Sold Food Crops	0.099*** (0.033)
No. of observations	**1,720**

Appendix 6: Livestock

Table 15: Determinants of TLU index

	Coefficient (Std. Error)
Treatment	-0.010 (0.075)
Year (2020)	-0.181*** (0.037)
County (Uasin Gishu)	0.539*** (0.083)
Respondent Age	0.024 (0.016)
Respondent Age Squared	0.000 (0.000)
Respondent Female	0.044 (0.079)
Household Members	0.074*** (0.017)
Completed Primary Education	0.619*** (0.085)
Self-reported Land Size	-0.000* (0.000)
More than 50 Timber Trees at Baseline	-0.004 (0.116)
More than 100 Trees at Baseline	0.067 (0.119)
No. of observations	**3,440**

Table 16: Livestock uses

Livestock use[41]	Cows	Goats	Sheep	Donkeys	Chicken
Self-consumption	80%	74%	68%	7%	93%
Sale of animals or animal products	84%	59%	61%	0%	92%
Manure	84%	74%	63%	12%	28%
Work	9%	0%	0%	27%	0%
Transport and haulage	1%	0%	0%	80%	0%
Collateral	1%	4%	0%	0%	0%
Insurance	28%	23%	27%	0%	25%
Risk pooling	0%	0%	0%	0%	0%
Dowry	5%	0%	2%	0%	0%

[41] The survey also included questions on pigs, but no farmer in our sample owned pigs.

Social status	3%	1%	0%	0%	1%
Cultural/ceremonial	7%	2%	0%	0%	4%
Other	0%	0%	2%	0%	0%
No. of observations	**264**	**76**	**108**	**36**	**252**

Appendix 7: WTP and Earnings Models

Table 17: WTP model valuation

Tree Value (KES) / Age (Years)	Grevillea	Eucalyptus	Cypress
0	730	1,400	1,438
1	917	1,738	1,710
2	1,280	2,023	2,120
3	1,594	2,327	2,355
4	1,897	2,550	2,660
5	2,015	2,915	2,845
6	2,200	2,916	2,883
7	2,243	3,081	3,118
8	2,379	3,356	3,356
9	2,797	3,323	3,187
10	2,448	3,221	3,530
No. of observations	**1,028**	**1,014**	**800**

Table 18: Earnings model valuation

Tree Value (KES) / Age (Years)	Grevillea	Eucalyptus	Cypress
0	421	662	228
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3	1,062	1,302	868
4	1,243	1,484	1,050
5	1,409	1,650	1,216
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10	2,000	2,241	1,807
11	2,070	2,311	1,877
12	2,125	2,366	1,932
13	2,164	2,404	1,970
14	2,186	2,427	1,993
15	2,193	2,434	2,000
No. of observations	**488**	**508**	**117**

Appendix 8: Tropical Livestock Units

Region	Cattle	Buffalo	Sheep	Goats	Pigs	Donkeys	Horses	Mules	Camels	Chickens
Middle East North Africa	0.7	0.7	0.1	0.1	0.2	0.5	0.4	0.6	0.75	0.01
North America	1		0.15	0.1	0.25	0.5	0.8	0.6		0.01
Africa South of Sahara	0.5		0.1	0.1	0.2	0.3	0.5	0.6	0.7	0.01
Central America	0.7		0.1	0.1	0.25	0.5	0.5	0.6		0.01
South America	0.7		0.1	0.1	0.25	0.5	0.65	0.6		0.01
South Africa	0.7		0.1	0.1	0.2	0.5	0.65	0.6		0.01
OECD	0.9	0.7	0.1	0.1	0.25	0.5	0.65	0.6	0.9	0.01
East and South-East Asia	0.65	0.7	0.1	0.1	0.25	0.5	0.65	0.6	0.8	0.01
South Asia	0.5	0.5	0.1	0.1	0.2	0.5	0.65	0.6		0.01
Transition Markets	0.6	0.7	0.1	0.1	0.25	0.5	0.65	0.6		0.01
Caribbean	0.6	0.6	0.1	0.1	0.2	0.5	0.65	0.6		0.01
Middle East	0.55	0.6	0.1	0.1	0.25	0.5	0.56	0.6	0.7	0.01
Other	0.6	0.6	0.1	0.1	0.2	0.5	0.65	0.6		0.01

Appendix 9: Plant and Livestock Types

Table 19: Plant and Livestock Types

Classification	Types Included
Livestock	Cows, Goats, Sheep, Donkeys, Pigs, Chickens, Other Poultry, Rabbits, Horses, Camels
Staple	Maize
Cash	Coffee, Tea, Flowers, Sesame, Sugar Cane, Bhoma Rhodes Grass, Napier Grass, Pyrethum, Other Cash Crops
Leafy Greens	Spinach, Sukuma Wiki, Cabbages, Managu
Roots and Tubers	Beetroot, Carrot, Potatoes, Cassava
Vegetables	Broccoli, Cauliflower, Cucumber, Onions, Pumpkin/ Squash, Tomatoes, Watermelon, Pineapple, Other Vegetables
Legumes	Beans, Peas, Groundnuts
Forages	Napier Grass, Bhoma Rhodes Grass
Cereals	Millet, Sorghum, Wheat, Barely, Other Cereal Crops

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