Sidama Coffee Agronomy Program

Impact report

Gashaw T. Abate, Mekdim D. Regassa, Tanguy Bernard, Bart Minten

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INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE
IFPRI

A world free of hunger and malnutrition
IFPRI is a CGIAR Research Center
1201 Eye Street, NW, Washington, DC 20005 USA |
T. +1-202-862-5600 | F. +1-202-862-5606 | Email:
ifpri@cgiar.org | www.ifpri.org | www.ifpri.info

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Acronyms

BP	Best Practice
CBD	Coffee Berry Disease
CFC	Coffee Farm College
DID	Difference-in-Difference
FAOSTAT	Food and Agriculture Organization Statistics Database
FFG	Focal Farmer Group
FGD	Focus Group Discussion
FT	Farmer Trainer
HWG	HereWeGrow
IPDM	Integrated Pest and Disease Management
ITT	Intention-to-Treat
PCA	Principal Component Analysis
RCT	Randomized Controlled Trial
SROI	Social Return on Investment
TLU	Tropical Livestock Unit
TNS	TechnoServe
ToC	Theory of Change

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Executive summary

Coffee is Ethiopia's most important export crop, and it constitutes an important source of livelihood for an estimated 15 million people across the value chain, most of whom are poor smallholder farmers. While coffee production and exports generally increased over the last decade or so, several constraints are still keeping the sector from attaining its full potential. Low-yielding, aged coffee trees and poor farm management and agronomic practices are among the main constraints. Between 2019 and 2022, TechnoServe (TNS)—in collaboration with Max und Ingeburg Herz Stiftung/HereWeGrow (HWG)—implemented a 25-month coffee agronomy training program in the Sidama region of Ethiopia that comprised a package of interventions to address these constraints and increase smallholders' coffee productivity and income. In particular, the program covered five woredas/districts (Aleta Chuko, Dale, Bona Zuria, Hawela, Shebedino) and reached 47,759 farm households in two cohorts (2019 and 2020).

This evaluation assesses the program's impact on: (i) the adoption of promoted best practices; (ii) the effectiveness of exit strategies piloted at the end of program; (iii) the yield impact of stumping; and (iv) the program's overall Social Return on Investment (SROI). We use multiple quantitative datasets and qualitative narratives collected by the program's learning partners (IFPRI and Laterite) throughout the program's lifecycle. This executive summary presents the main highlights of this report: households' participation and experiences with the program; its impact on their knowledge and adoption of best practices; the resultant changes in yields; and the overall SROI.

Farmer mobilization/sign-up and program participation. The farmer mobilization/sign-up process was viewed as fair and inclusive: most of the eligible coffee-producing households that signed up for (expressed interest in) the program were able to register and take part in it. The program essentially relied on preexisting development groups that were organized or formed by the local/kebele administration for farmer mobilization and used for program implementation as Focal Farmer Groups (FFGs). Using an existing group structure (to the extent possible) is beneficial in terms of reducing costs associated with group formation and ensuring continuity of group discussions/interactions beyond a program's lifecycle. Households' participation rates in trainings were moderate for the 2019-cohort (ranging from 36 percent for record keeping to 64 percent for stumping), and higher for the 2020-cohort (ranging from 59 percent for integrated pest and disease management (IPDM) to 84 percent for coffee nutrition).

Impact on best practices adoption. The program demonstrated a clear and meaningful effect on adoption of best practices, with some variation across cohorts. In the 2019-cohort, the program significantly increased adoption of stumping (by 9 percentage points), coffee nutrition (14 percentage points), weeding (8 percentage points), soil erosion control (7 percentage points), IPDM (11 percentage points), and record keeping (20 percentage points) based on difference-in-difference estimates that compare and contrast topic-trained households with untrained households before and after the intervention. Similarly, the program significantly increased adoption of stumping (by 32 percentage points), shade management (20 percentage points), IPDM (8 percentage points), and record keeping (5 percentage points) in the 2020-cohort. The program increased the number (share) of stumped coffee trees by 7.5 trees (2.5 percentage points) in the 2019-cohort and by 14 trees (5.5 percentage points) in the 2020-cohort. While some of these results represent a more than twofold increase in adoption rate and intensity after the training intervention (partly due to the low baseline), complementary interventions that can drive adoption at scale are needed as a much higher adoption intensity is required to ensure sufficiently strong yield and income effects. There is also a need to properly measure the program's impact on the adoption intensity of key practices such as composting, weeding, and shade management (in addition to stumping).

Impact pathways. Knowledge improvement from attending the trainings and increased access to tools (for example, stumping saws) are found to be the main pathways to impact/adoption. For instance, households knowledgeable on coffee nutrition are 36–37 percent more likely to adopt the practice than their counterparts. Similarly, significant correlations are observed between increased knowledge and adoption for soil erosion control, record keeping, and stumping in both cohorts. The results show a statistically significant association between increased access to a stumping saw and stumping adoption: access to this tool increased adoption of stumping by about 7–8 percentage points in both cohorts.

Impact of exit strategies. For the 2019-cohort, the program introduced two exit strategies—farm support and farm ambassador—after completion of the 25 months of Coffee Farm College (CFC) trainings to provide continued support and keep momentum on adoption of best practices. The experimental evaluation that assessed the effectiveness of these interventions showed no statistically significant effect on stumping and coffee nutrition, the main outcomes the exit intervention intended to improve. The late start (in the case of farm support) and the light-touch nature of the intervention (in the case of farm ambassador) are potential reasons for no impact. Moreover, as informed by qualitative narratives, most farmers indicated their preference to wait and see the impact of the practices on yield firsthand after the initial trial before adopting continuously and at scale.

Impact of incentives (tools) for stumping. For the 2020-cohort, the program offered packages of agricultural tools as an incentive to encourage the adoption and intensity of stumping together with the final rejuvenation training. The experimental evaluation indicates that the incentive packages increased the "intensive margin" of stumping adoption up to a certain threshold but did not by themselves increase the "extensive margin" of adoption (trial) of stumping once farm households' participation in rejuvenation training was accounted for. In other words, the incentive was only impactful on households that were trained on rejuvenation and had already tried stumping. This indicates that training is indispensable to start adoption of stumping by introducing and encouraging the uptake of new farming practices. While we observe a synergistic effect from the rejuvenation training and incentives for stumping up to a certain threshold (that is, 150 coffee trees), they do not immediately yield sufficient adoption uptake and intensity to ensure strong yield and income effects.

Stumping and coffee yield. A pilot yield assessment survey conducted during the 2022/23 coffee harvest on adjacent plots with stumped and unstumped coffee trees indicates that stumping increases coffee tree yields by about 21 percent after accounting for tree characteristics (for example, age, height), adoption of other complementary best practices (that is, weeding, shade management, composting), and location. A rigorous assessment (evidence) on yield impacts of other best practices and the long-term yield impact of stumping is needed to promote adoption of best practices at scale.

Social Return on Investment. An SROI valuation indicates that the program is not cost-effective and the program benefits amount to only 72 percent of the program costs at the commonly used 10 percent discount rate. The low uptake and intensity of stumping and the small change in overall farm management limit the program's potential to accrue benefits that can meaningfully exceed its costs. However, the SROI results should be interpreted with caution, as they are based on the impacts observed only during the two to three years of program implementation and related assumptions. For instance, the SROI can become positive if farmers change their adoption pattern and start adopting at scale after they observe the yield benefits of best practices on their own or neighboring farms.

1. Introduction

Coffee is Ethiopia's most important export crop, accounting for one-third of the country's commodity exports in 2021/22 (NBE 2022).[1] It is estimated that Ethiopia's highly valued Arabica coffee is cultivated by over 6 million farmers and employs about 15 million people across the value chain (CSA 2022; FSA/USDA 2018). The sector comprises an important source of livelihood for these large number of actors, most of whom are poor smallholder farmers. While coffee production and exports generally increased over the last decade (Minten et al. 2019), several constraints are still keeping the sector from attaining its full potential. Low-yielding, aged coffee trees and poor farm management and agronomic practices are among the main constraints (Davis et al. 2018). For instance, most coffee trees currently grown in Ethiopia were planted over two to three decades ago, and farmers have rarely been taught how to rejuvenate their coffee trees to improve their yields sustainably (Minten et al. 2019; Amamo 2014; Woldetsadik and Kebede 2000). In 2021, official coffee yield estimates in Ethiopia were on average 60 percent below that of Brazil (the world's top coffee producer) and 24 percent below the world's average yield (FAOSTAT 2022).[2]

Ethiopia's coffee landscape is organized into five main coffee-producing zones (North, Southwest, Rift, Southeast, and Harar). Most coffee production is clustered in the southwest and southeast parts of the country (Minten et al. 2019; Davis et al. 2018). Sidama is among the major coffee-producing areas of southeast Ethiopia and is known for its distinctive cultivation system: small coffee farms that feature mixed crops in association with forest trees and vegetation and produce coffee with a distinctive flavor profile (Davis et al. 2018). As in most coffee-producing zones, however, coffee yields are low in Sidama because of aging coffee trees/stock, poor agronomic practices, and climatic constraints (for example, low rainfall, long dry season, etc.).

To address some of these constraints, TechnoServe (TNS)—in collaboration with Max und Ingeburg Herz Stiftung/HereWeGrow (HWG)—implemented a 25-month coffee agronomy training program in the Sidama region of Ethiopia that comprises a package of interventions. Specifically, the program aims to address the constraint of aging trees and poor agronomic practices through an intensive coffee agronomy training program. The program is promoted through TNS's Coffee Farm College (CFC) training approach, which aims to improve coffee productivity and resilience by promoting proven agronomic practices—such as rejuvenation/stumping, coffee nutrition and health, shade management, weeding, and erosion control—through participatory and experiential learning methods. The core elements of the CFC approach are: (i) training held in small groups at a focal farmer's demonstration plot, which is used for practical sessions and where coffee farmers can see firsthand the results of implementing best agronomic practices on the health and productivity of coffee trees; and (ii) repeated training during the

[1] The share of coffee in total merchandise export increase significantly in 2021/22—to 34.9 percent from 25.3 percent in the preceding year—due to an increase in international coffee prices (by about 29 percent) and an increase in export volume (by about 22 percent) (NBE 2022).
[2] Coffee yields in Ethiopia are higher than the average yield in Africa and in the continent's main coffee-producing countries, such as Uganda, Côte d'Ivoire, and Kenya (FAOSTAT 2022).

season, each time with new topics or lessons that are relevant to the particular coffee production calendar.[3]

In this evaluation, we assess the program's impact on adoption of seven best practices (rejuvenation, coffee nutrition, weeding, integrated pest and disease management (IPDM), shade, soil erosion control, and record keeping) that are identified as key practices to revitalize coffee farms and thereby increase productivity and income. (The program also promotes planting new coffee trees and intercropping with recommended/selected crops.) We assess the (marginal) impacts of complementary/add-on interventions such as provision of incentives for stumping and pilot exit strategies. The program was implemented in two separate cohorts (2019-cohort and 2020-cohort) and this report covers results from both. For the 2019-cohort, the program was implemented from January 2019 to March/April 2021 and comprised 34 kebeles in two districts. The 2020-cohort was implemented from January 2020 to March/April 2022 and comprised 49 kebeles in four districts. All coffee farmers in these districts and kebeles were eligible for the training program and participation was voluntary (leading to participant and nonparticipant groups of farmers).

The evaluation relies on a combination of quantitative and qualitative data. The quantitative analyses mainly use (i) the baseline and endline data collected by Laterite in collaboration with IFPRI and TNS, and (ii) the baseline and endline stumping survey data collected by IFPRI. Data collected as part of the incentives for the stumping pilot and evaluation of exit strategies are also used for specific/complementary analyses. The qualitative analysis uses data collected at different points in time through focus group discussions (FGDs), in-depth interviews, and direct observations.

We estimate the impact of the CFC program using two approaches. The first approach is a simple before-and-after comparison that tracks the evolution of outcomes of interest among program participants over time. However, this approach assumes that the outcomes would have been exactly the same as their preprogram situation had the program never existed, a strong assumption since, in most cases, changes over time are inevitable. The second approach addresses this concern by comparing program participants to nonparticipants through a difference-in-difference (DID) approach, using the program's baseline and follow-up data from both training participants and nonparticipants. In these estimates, we first match participants and nonparticipants on a set of observable characteristics likely correlated to both our outcome variables and program participation. However, we recognize that this estimation strategy still has limitations in that it does not account for self-selection biases on unobservable characteristics, wherein farmers' unobservable characteristics may drive their decision to participate in the program. Again, this is mainly because farmer-level participation in training was voluntary (farmers self-selected into the program) and the experimental design lacked a pure control group of farmers.[4]

These limitations aside, we find a strong and statistically significant association between participation in training and adoption of best practices promoted by the program. For instance, the program led to a 9-

[3] For instance, the rejuvenation training (the main topic among the seven modules) is conducted during the stumping season, which spans from January to March.
[4] If, for instance, farmers who join the program are more entrepreneurial or eager-to-learn farmers, the comparison with nonparticipants likely yields an upper-bound estimate of the true impact of the program.

and 32-percentage point increase in the share of topic-trained households adopting stumping practices over the three stumping seasons during the program compared to their counterparts in the 2019- and 2020-cohorts, respectively.[5] Likewise, the program increased the number (share) of stumped coffee trees by 7.5 trees (2.5 percentage points) in the 2019-cohort and by 14 trees (5.5 percentage points) in the 2020-cohort. As stumping is rarely practiced in Ethiopia (that is, low baseline values), some of these results represent a more than twofold increase in the adoption rate and intensity of stumping after the training intervention. However, the magnitudes of these impacts are low in absolute terms, especially on adoption intensity (number and share of stumped trees). In fact, we observe a declining trend on adoption of stumping after the first year, which we understand from the qualitative narratives as evidence that most farmers are reluctant to forgo their coffee harvest because of stumping (or to absorb the production loss due to stumping), even if their current harvest is lower than the optimal yield. Farmers also want to wait and see the impact of stumping on yield firsthand before stumping continuously and at scale on a yearly basis.

The results point to a clear and meaningful impact on adoption of the other best practices by topic-trained households. In the 2019-cohort, the training program significantly improved adoption of coffee nutrition (by 14 percentage points), weeding (8 percentage points), soil erosion control (7 percentage points), IPDM (11 percentage points), and record keeping (20 percentage points). Similarly, the program significantly increased adoption of shade management (by 20 percentage points), IPDM (8 percentage points), and record keeping (5 percentage points) in the 2020-cohort. Since adoption of good agricultural practices is generally low in the program area, these impacts represent a substantial improvement over households that were not topic trained.

The results of the complementary/add-on interventions implemented as an exit strategy or to increase stumping paint a mixed picture. The farm support and ambassador interventions introduced at the end of the CFC training as an exit strategy to keep the momentum of adoption of best practices had no meaningful effects on farmers who were offered the support compared to their counterparts. On a positive note, the incentive (tools) for the stumping intervention introduced in the last stumping season of the CFC program significantly increased the intensity of stumping adoption, albeit up to a certain threshold. However, we find no statistically significant impact of the incentive packages on adoption of stumping once we account for farm households' (self-reported) participation in rejuvenation training, clearly indicating that training is indispensable for introducing new practices to farmers and encouraging them to try them.

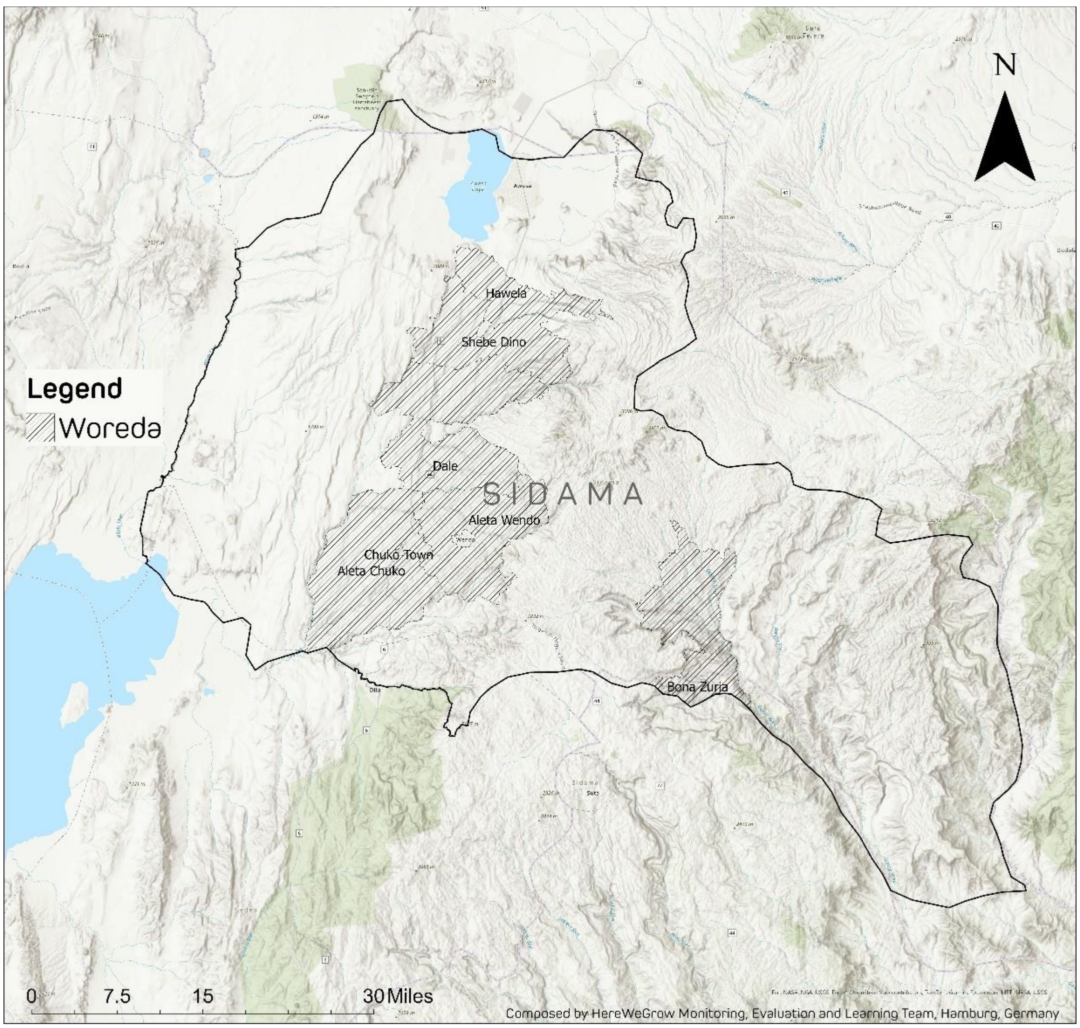
The remainder of the report is organized as follows. Section 2 briefly describes the intervention and its core components. Section 3 presents the evaluation methodology, including the evaluation design, sampling and data, and estimation strategies. Section 4 presents descriptive results on sample households' demographic and socioeconomic characteristics and participation in the program. Section 5 discusses the impacts of the CFC program and complementary/add-on interventions. Section 6 concludes with some practical and policy implications.

[5] During the endline we asked respondents whether any member of the household participated in the trainings provided by the program for each main topic or best practice (that is, rejuvenation, weeding, coffee nutrition, etc.). Topic-trained households are households that took part in at least one training of a given topic during the program.

2. The program and scope of the evaluation

The program is essentially coffee agronomy training implemented by TNS following its CFC approach, which aims to improve coffee productivity and resilience by promoting proven agronomic best practices. The program was implemented in the Sidama region of Ethiopia in two cohorts (2019-cohort and 2020-cohort) that each received a 25-month training. In particular, the program covered five woredas/districts (Aleta Chuko, Dale, Bona Zuria, Hawela, Shebedino) and reached 47,759 farm households that registered with the program. Figure 2.1 shows the woredas targeted by the program. This section briefly describes the program's Theory of Change (ToC), core elements of the interventions, and add-on interventions introduced during the program to maximize impacts (that is, farm support, farm ambassador, and incentives for stumping).

Figure 2.1. Sidama coffee agronomy program's target woredas

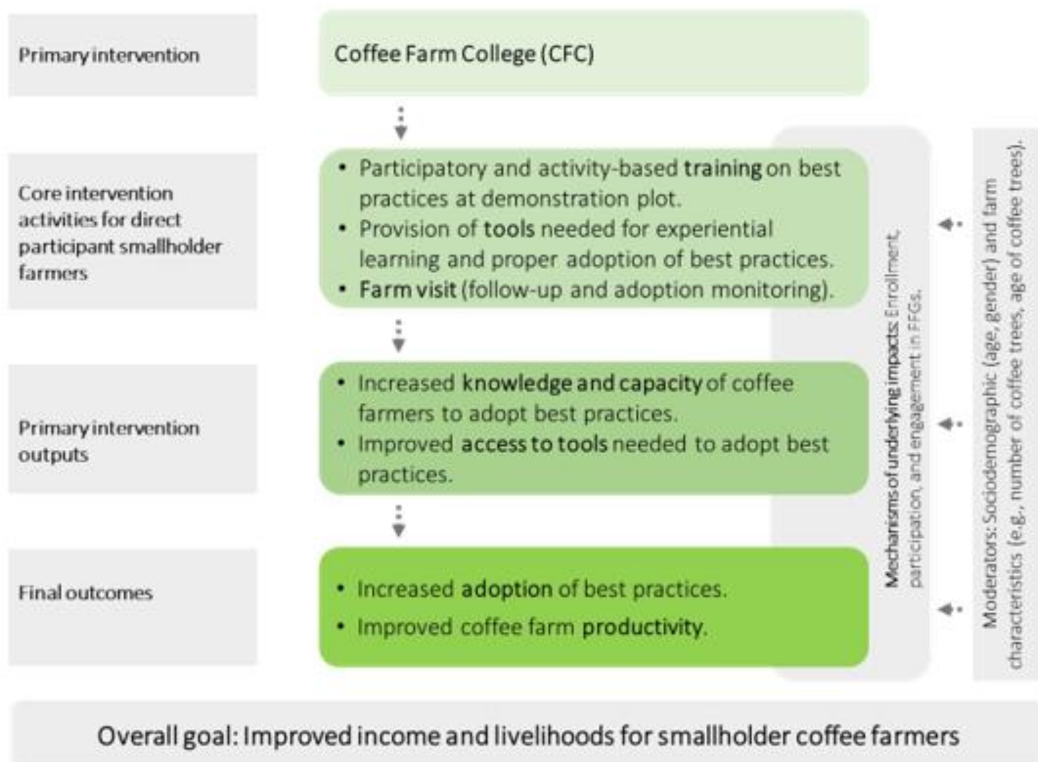


Source: HereWeGrow.

2.1. Program Theory of Change

Figure 2.2 outlines the ToC of the agronomy program for coffee farm households that participate in the trainings, with the overall goal of improving coffee farm productivity, income, and livelihoods. The primary intervention is TNS's CFC training program, which comprises four core interlinked components: (i) activity-based training on best practices using adapted and validated curriculum; (ii) localized group training delivered at demonstration plots; (iii) provision of tools needed for experiential learning at the farmer group level; and (iv) follow-up and adoption monitoring through farm visits (see a detailed description of these core intervention in the next subsection). These core interventions are expected to improve farm households' knowledge, capacity, and access to tools needed to properly adopt best practices. Improvement in knowledge and access to tools should result in adoption of best practices and thereby improve coffee farm productivity.

Figure 2.2. Theory of Change for Sidama's coffee agronomy program



These outputs and outcomes of the interventions are mediated by impact dimensions or mechanisms that condition the population on which impact is going to be observed. Importantly, they depend on whether and how farm households enroll/register, participate, and engage in Focal Farmer Group (FFG) activities. These mechanisms can be viewed as enablers of the outputs and outcomes. For example, when exposed to activity-based training at demo plots [*activity*] through engagement and participation in FFG training sessions [*mechanism*], a farm household may gain knowledge on best agronomic practices [*output*] that leads to their adoption [*outcome*]. Impact pathways are also influenced by moderators at the farm (for example, number of coffee trees, age of coffee trees), household (for example, household heads' age, gender, and education level) and community level (for example, remoteness). These moderators are unlikely to change over the program period and can be thought of as a set of characteristics that might determine program success or the magnitude of impacts among groups with distinctive characteristics. In other words, these are potential sources of impact heterogeneity.

2.2. Core interventions of the agronomy program

As indicated above, the core intervention of the CFC is an intensive, activity-based training approach designed to improve adoption of best agronomic practices that can enhance the productivity of coffee trees in a sustainable manner. The CFC comprises four main interlinked components: (i) adaptation of curriculum and content; (ii) localized monthly training implemented at the focal farmer level and provided in group sessions; (iii) provision/introduction of the necessary training tools and equipment; and (iv) follow-up farm visits and monitoring of adoption.

- *Curriculum and content development*. At the core of the CFC is the design of its curriculum and its content. The syllabus was developed by TNS in consultation with the Jimma Agricultural Research Centre (JARC) and the Ethiopian Tea and Coffee Authority and drew on Africa-wide experience in farming coffee and more than 13 years of CFC implementation. The syllabus and the contents were validated through a review process by regional training and agronomy advisors and the local Ethiopian TNS team, who knew the local context before they were finalized for instruction. Besides relevance, much emphasis was given to simplifying the lessons to make the content accessible to farmers with limited literacy and numeracy levels. A unique feature of the curriculum was its (mutually reinforcing) topic-specific lesson plans for each best practice, and the instruction of each lesson or module shortly before the appropriate time/calendar for implementation. The curriculum also included modules aimed at inculcating farmers with basic business skills. Training sessions largely relied on activity-based or learning-by-doing instructions that allowed the active engagement of each farmer in practical applications.
- *Localized training*. Farmers received training on coffee agronomy and farm management practices in their locality and in small groups, known as FFGs (or development groups), to facilitate and ensure active participation. These groups are a semi-formal local administrative structure within each kebele that comprises about 30 coffee-farming households, on average, and serve as a grassroots forum to discuss local development initiatives. For this intervention, each group had a Focal farmer who hosted the demonstration plot, where coffee farmers could see firsthand the results of properly implementing best agronomic practices on coffee trees' growth and productivity. The training was organized and facilitated by dedicated Farmer Trainers (FTs) who were trained and continuously mentored by TNS coffee agronomists.[6] Each FT worked with up to 12 FFGs and conducted training every month for 25 months, each time with new topics synchronized with the coffee production calendar. During the second year of the 2019-cohort and first year of the 2020-

[6] FTs were locally recruited personnel who organized and facilitated training sessions at the FFG level. They were trained by TNS agronomists (agronomy advisers) on coffee agronomy basics and on adult training techniques through an eight-day Training of the Trainer and Agronomy course before they became trainers. FTs received continuous mentorship and supervision throughout the 25-month program. For instance, FTs received a training on each monthly coffee agronomy topic that they subsequently delivered to the FFGs.

cohort, however, the group training approach was interrupted due to COVID-19 and was replaced by individual farm visits.

- *Provision/introduction of tools and equipment*. The program introduced tools (for example, stumping saws, secateurs, wheelbarrows) necessary for the proper implementation of promoted agronomic practices, such as stumping. To encourage adoption, the program facilitated farmers' access to the required tools through their respective FTs and Focal farmers. In particular, the program provided a set of tools for each FFG through the Focal farmer, who served as a custodian of the tools and facilitated borrowing by group members interested in implementing the best practices. The provision of tool packages directly to individual farm households (in addition to the tools provided to FFGs) was also introduced at the end of the program as an incentive to encourage stumping.
- *Follow-up support and monitoring*. FTs and TNS coffee agronomists provided follow-up implementation support right after the delivery of training on specific core agronomic practices. Concurrently, the FTs advised individual farmers on adoption of agronomic practices covered in the training sessions by visiting their coffee farms.

2.3. Add-ons: Farm support, farm ambassador, and incentives

After completion of the core interventions, the agronomy program implemented additional activities to sustain and deepen impacts (farm support and/or ambassador) and to encourage farmers to increase the intensity of stumping (incentives/tools). The farm support intervention was implemented in target woredas of the 2019-cohort, providing on-farm advisory visits to farmers following the final CFC training for three to four months. The farm support was appointment-driven: farmers who had taken part in the agronomy program were encouraged to book a farm support visit from their FT. During the visit, the FT observed the coffee farm with the farmer(s) and provided guidance on the best practices taught during the CFC, with a focus on stumping, composting, and weeding. FTs also carried stumping tools to provide hands-on advice on stumping, and when required, to help farmers stump on their farms.

The farm ambassador intervention followed the three to four months farm support program and was designed to provide longer-term support (exit strategy) after conclusion of the CFC training program. The farm ambassador interventions—aimed to increase long-term retention of the best practices knowledge and thereby adoption—ran for 12 months via chosen ambassadors who served as resource persons and peer motivators for each FFG. Farm ambassadors are usually highly motivated farmers willing to commit their farm as a demonstration plot and advance their community by serving as a source of knowledge and inspiration. In this program, farm ambassadors were farmers who had served as a Focal farmer during the core CFC training program; they received further technical support from TNS agronomy advisors (including training on communication, leadership, and inspiration) and small incentives (signs of appreciation) for maintaining their farm as a demonstration plot and providing a positive example for their community.

The agronomy program also offered packages of tools needed for maintaining coffee farms as a means to further encourage adoption and intensity of stumping in woredas targeted by the 2020-cohort, again after the core CFC training program was completed. The incentive packages consisted of a combination of tools (stumping saws, secateurs, and wheelbarrows). Farm households were eligible to receive the tools after they stumped a certain number of coffee trees (that is, when they met a threshold).

These three add-on interventions were accompanied by experimental studies that aimed to measure their effects on the outcomes of interest (sustained adoption of best practices and stumping intensity) and their cost effectiveness. The evaluation designs accompanying these interventions are discussed in Sections 5.3 and 5.4, before presentation of the results.

2.4. Domains of interest and measurement: Outputs and outcomes

As indicated in the ToC, the primary outputs of the program include: (i) increased knowledge and capacity of coffee farmers on key best practices taught by the CFC; and (ii) improved access to tools needed to properly adopt the best practices. We measure farmers' knowledge on best practices using a semi-standardized knowledge module that consisted of 12 questions covering all seven of the key best practices assessed in this impact report. We also develop an overall knowledge index using principal component analysis (PCA). (Appendix Table A.1 presents the knowledge questions with the correct answers.) We measure access to tools (that is, stumping saws) by directly asking respondents whether the household has access to a stumping saw, either owned by the household or by other farmers in the community. (We also asked the main provider of the stumping saw in cases where the tool was not owned by the household.) These outputs (improved knowledge and access to tools) are understood to be a first step (mechanism) in the impact pathway to final outcomes.

At the outcome level, the program aimed to increase adoption of best practices and coffee yield. Both of these outcomes flow directly from the abovementioned program outputs; that is, increases in knowledge and access to tools are expected to increase adoption of best practices, and thereby coffee yield. We measure adoption of the seven key best practices taught by the CFC training program following the adoption rules recommended by TNS (the program implementing partner). The key best practices and respective adoption rules are presented in Appendix Table A.2.

The yield assessment primarily focuses on understanding the impact of stumping on coffee trees' productivity. It was implemented on a subset of sample households that: (i) stumped at least 40 coffee trees during the 2019 stumping season (January to March); and (ii) have farms with two comparable 10 meter (m) x 10m areas (plots) with stumped and unstumped areas ideally located as adjacent sections of the same coffee farm. The coffee yields from these plots were measured following a full-harvest approach at the plot level (stumped area versus unstumped area) with the assistance of an FT (equipped with a weighing scale) throughout the duration of the harvest. In other words, yields are based on objective measures of coffee harvest at the plot level. For the overall sample, we measure perception of coffee yield change by directly asking farmers the rate of change in coffee yield that they experienced after joining the CFC training program (or in the two years prior to the endline surveys if they had not self-reported to have participated in the program).

3. Evaluation methodology

3.1. Evaluation designs

The main evaluation approach is based on a "quasi-experimental" design that combines two counterfeit counterfactuals (that is, before-and-after comparisons and with-and-without comparisons) to produce better estimates of how key outcomes of interest would have evolved in the absence of the coffee agronomy program. The main advantage of this approach is that it accounts both for time-invariant (through the before-and-after comparison of households that participated in the training program) and time-varying confounding factors (through comparison with households that did not participate in the training program) that can simultaneously determine training participation and key outcomes. However, this approach fails to account for farm- and household-level unobservable characteristics that may drive not only decisions to participate in the training but also the outcomes in the program's absence (that is, farmers' likelihood of adopting the best practices in the program's absence).

The evaluations of the add-on interventions to test/evaluate potential exit strategies (that is, farm support and farm ambassador model) and the impact of incentive provision on stumping are based on experimental designs.

Exit strategy: The assessment of the exit strategy employs a cluster randomized controlled trial (RCT) that allocated the 34 program kebeles that were part of the 2019-cohort into the following three study arms after the last training of the main CFC program:

Treatment arm 1: Farm support (12 kebeles)
Treatment arm 2: Farm support + farm ambassador model (11 kebeles)
Control arm: No post-CFC support (11 kebeles)

Using this design, we assess the impact of the farm support intervention on the outcomes of interest for any households assigned to the treatments (treatment 1 + treatment 2), and the distinct treatment effects (treatment 1, treatment 2) separately.

Incentive provision: Similarly, the assessment of the impact of incentive on stumping was based on a cluster RCT that assigned the 49 program kebeles that were part of the 2020-cohort into the following four stumping incentive eligibility thresholds and a control group.

Control: Households receive a saw and secateurs for stumping at least 50 coffee trees
Group 1: Households receive a saw, secateurs, and a wheelbarrow for stumping 100 coffee trees
Group 2: Households receive a saw, secateurs, and a wheelbarrow for stumping 150 coffee trees
Group 3: Households receive a saw, secateurs, and a wheelbarrow for stumping 200 coffee trees
Group 4: Households receive a saw, secateurs, and a wheelbarrow for stumping 250 coffee trees

With this design, the evaluation assessed the overall impacts of incentive offerings as well as the cost-effective threshold (number of coffee trees) households are willing to meet in exchange for a given incentive package.

The analysis on the impact of stumping/rejuvenating coffee trees on yield is based on a tailored design that compares coffee yields from two 10m x 10m adjacent plots: a "stumped plot" mainly composed of coffee trees stumped during the first year of the program (January–March 2019) and an "unstumped plot" mainly composed of older coffee trees that were yet to be stumped. The coffee yields from these plots were measured following a full-harvest approach at the plot level (stumped area versus unstumped area).

3.2. Sampling and data

While the sampling frames from which we selected households varied across the two cohorts and the different add-on components of the evaluation, we followed a similar sampling strategy, except for the yield impact assessment. First, we identified all eligible households: all coffee farmers in all FFGs/development groups of each program kebeles for the main CFC evaluation (2019- and 2020-cohorts); "trained" households from the TNS attendance database for the evaluation of farm support and farm ambassador model interventions (2019-cohort); and the list of farm households that "participated" in the TNS CFC program for the evaluation of the incentive provision (2020-cohort).[7] The sampling frame for the yield impact assessment comprises households with eligible coffee farms where the household had stumped at least 40 coffee trees in the 2019 stumping season (2019-cohort).

Second, we selected households using a two-stage sampling process: we first randomly selected development groups in each kebele, from which we then randomly selected households. The number of development groups per kebele and households per development group varies across the two cohorts and add-on components of the evaluation (Table 3.1). The selection of samples for the yield assessment involved a quick screening survey of households with eligible coffee fields to identify households with two comparable 10m x 10m coffee plots that are stumped and unstumped, with the unstumped plot ideally located in an adjacent/neighboring section on the same coffee field. The screening survey resulted in 111 coffee farms.

Table 3.1. Sampling strategy and size by cohort and add-on interventions

Cohort/add-on interventions	Number of woredas	Number of kebeles	Number of sample FFGs per kebele	Number of sample households per FFG	Total sample households (coffee farms)
2019-cohort	2	34	7	4	893
2020-cohort	4	49	5	4	932
Farm support/ambassador	2	34	8	4	1040
Incentive for stumping	4	49	5	4	940
Yield impact of stumping	2	34	-	-	(111)

Note: The farm support and farm ambassador model and yield impact assessment were implemented in the 2019-cohort; the incentive for stumping was implemented in the 2020-cohort.

Several rounds of data collection were conducted, in line with the main research/learning questions derived from the ToC and to further assess the impacts of the add-on interventions that aimed to

[7] A farm household is considered trained if a member of that household attended more than one-half of the 10 training topics delivered as part of the CFC program. (The topics include rejuvenation, composting, coffee planting, business skills, weeding, IPDM, nutrition, shade management, soil erosion control, and harvesting.) On the other hand, a farm household is considered a participant if a member of that household participated at least in one of the training topics delivered as part of the CFC program.

increase stumping intensity (incentive provision) or ensure sustainable adoption of best practices (farm support and/or farm ambassador model). For the evaluation of the CFC program, we collected data before the start of the program (baseline) and after its completion (endline). The endline for the 2019-cohort was conducted right after completion, while the endline for the 2020-cohort was conducted one year later. Both surveys collected rich information on sample households' demographic and socioeconomic characteristics (for example, household head's age, education, and employment and marital status, household size, etc.) and adoption of best practices promoted by the program. Information on adoption of practices is based on farmers' self-report as well as on direct observation of the reference coffee field by trained data collectors. (The reference coffee field is the field where households mainly adopt the best practices taught by the CFC.) Specific baseline and endline stumping surveys were also conducted to precisely measure adoption and intensity of stumping right after the stumping season was completed. In these surveys, enumerators counted the total number of coffee trees and stumped coffee trees on the reference coffee field and measured the size of the field using GPS devices.

Similar sets of data were collected by the two follow-up surveys conducted to measure the impact of the farm support intervention (about four months after completion of the main program) and the farm ambassador model (about 12 months after the first follow-up), which were implemented to ensure sustained adoption of promoted best practices by households that participated in the 2019-cohort. The follow-up surveys collected additional information on whether farmers received a follow-up visit and interacted with members of the FFG after completion of the main CFC program. Enumerators were also asked to count the number of coffee trees stumped each year to have a more accurate estimate of stumping adoption intensity.

Yield data come from a full-harvest assessment that took place over a four-month period (October 2022–January 2023) with close support from FTs. The measurement involved multiple visits to coffee farmers. In the first visit the FT confirmed the location of the farm, marked the stumped plot, collected basic information related to stumping, and asked the farmer to contact him/her ahead of time when s/he decided the harvest dates. On a given harvest day, the FT assisted in the harvest and ensured that the cherries from the stumped and unstumped plots were bagged, weighed, and recorded separately.

Qualitative data were collected throughout the program's lifecycle, mainly to understand drivers and constraints of best practices adoption. The data were collected using FGDs and in-depth case studies.

3.3. Method of analysis (estimation strategy)

We use descriptive analysis to show changes in key variables of interest (for example, participation in trainings, access to farm tools, etc.) and sample household characteristics that closely relate to or might determine project participation, outputs, and impacts. We use econometric analysis to estimate the impact of the program on key outcomes of interest (for example, adoption of best practices, yield, etc.). Specifically, we use two estimation strategies to assess the impact of the CFC program: before-and-after comparison and a DID estimation strategy.

The before-and-after comparison estimates the impact of the program by simply tracking the changes in outcomes of interest for program participants over time (that is, before and after program implementation). The estimated before-and-after comparison is formally represented in Equation (1).

$$y_{it} = \alpha + \tau Post_t + \theta X_{it} + \varepsilon_{it} \tag{1}$$

where y_{it} is the outcome of interest (that is, adoption of best practices) for sample household i at time t; $Post_t$ indicates the timing of the outcome measures (Post equals one if the outcome value is taken at endline after the CFC program is completed, and zero if the outcome value is taken at baseline); X_{it} denotes a vector of household-specific/level control variables (that is, age, education, and gender of the household head, household size, membership in cooperatives, livestock ownership, asset index), plot-level characteristics (that is, age of coffee tree, farm size, number of coffee trees, and number of coffee fields/plots), and location characteristics (that is, distance to mill, distance to all-weather road, distance to woreda capital, and distance to coffee fields/plots); and ε_{it} is a random component.

The main limitation of the before-and-after comparison is that it assumes that the outcomes (y) for program participants would have been exactly the same as their preprogram situation if the program had never existed (Gertler et al. 2016). However, this assumption may not hold for our key outcomes of interest. We therefore exploit the presence of training participants and nonparticipants in eligible program areas and employ a quasi-experimental DID approach that addresses the limitation of the before-and-after comparison as our main estimation strategy. The DID approach compares outcomes of interest between participants and nonparticipants before and after the training intervention. The estimated DID is formally represented in Equation (2):

$$y_{ist} = \alpha + \rho Training_s + \tau Post_t + \delta(Training\ x\ Post)_{st} + \theta X_{ist} + \varepsilon_{ist} \tag{2}$$

where y_{ist} is the outcome of interest as described above. $Training_s$ indicates participation status in the rejuvenation training (*Training* equals one if the sample household participated in the training, and zero otherwise). $Post_t$ indicates the timing of the outcome measures (*Post* equals one if the outcome value is taken at endline after the training intervention, and zero if the outcome value is taken at baseline). $(Training\ x\ Post)_{st}$ is the interaction term of training (treatment indicator) and survey round (baseline versus endline), capturing the treatment effect of the training intervention. X_{ist} denotes a vector of household-, plot-, and location-specific/level control variables. ε_{ist} is a random component as described above. It is worth noting that the results for this estimate are only valid if the parallel trend assumption is satisfied. While it is difficult to test this for outcomes such as coffee nutrition, we can reasonably argue that it is the case for novel/new practices such as stumping.

The estimation approaches for assessment of the exit strategies, incentive provisions, and yield impact of stumping are briefly discussed in their respective sections before presenting the results. In general, we estimate the intention-to-treat (ITT) effects using an ordinary least square regression that accounts for vector of household-, plot-, and location-specific/level control variables.

The qualitative data collected at different points in time throughout the program are analyzed and presented in a narrative form, with indication of whether views expressed by participants of FGDs and key informants' interviews were widespread or selective.

4. Sample descriptions (descriptive results)

4.1. Description of sample households

Table 4.1 presents the demographic and socioeconomic characteristics of households included in the analysis by cohort. Overall, similarities arise across cohorts: the average household in our sample is headed by a 44-year-old person (typically a man) and includes about six family members, of whom three are children. While about two-thirds of household heads have a formal education, the share of household heads who attended secondary education is less than 20 percent across cohorts. We observe gender disparities in education: only one-third of spouses have a formal education, and a small fraction (about 5 percent) have an above-elementary education. Similarly, literacy (being able to read and write in at least one language) is higher among household heads (~70 percent) than among spouses (~30 percent). Education level among school-aged children is generally high for both male and female children (>80 percent).

Cooperative membership varies considerably across cohorts: while 54 percent of households in the 2019-cohort are members, only 26 percent of sample households in the 2020-cohort are. Cooperative membership among women is relatively low and, somewhat surprisingly, women tend to be a member in households where men are also members, even if membership of one household member is enough to access most of the services provided by cooperatives. One of the benefits cooperatives provide is a second payment (dividend): more than 80 percent of households with cooperative membership reported receiving such a second payment.

The surveys asked households' asset ownership, including housing, durable assets, livestock, and assets used for communication and transportation. Overall, housing quality is low (for example, only about one-half of the houses are covered by corrugated iron) and households largely depend on traditional sources of energy and lighting (for example, almost all use firewood for cooking and only one-quarter have access to improved lighting). Access to improved water sources is somewhat higher, although the average household has to travel about 25 minutes round-trip to fetch water. About two-thirds of households own a mobile phone, while only a small faction owns a radio (25 percent) or a television (~3 percent). About one-half of households own a plough, one-quarter own a saw, and ownership of pruning scissors and wheelbarrows is very limited. (The durable assets owned by households are included as an index generated by a PCA.) Most household own livestock and the average household owns more than 1.9 livestock in Tropical Livestock Units (TLU).

The size of total agricultural land cultivated by sampled households is generally small and varies slightly across cohorts: the average household owns 0.87 hectares (ha) and 0.69 ha of agricultural land in the 2019- and 2020-cohorts, respectively. Similarly, the average size of land dedicated to coffee farming is higher in the 2019-cohort (0.38 ha) than in the 2020-cohort (0.28 ha). The average best practice plot consists of 481 and 424 coffee trees in the 2019- and 2020-cohorts, respectively. These coffee trees are about two decades old on average, with some as old as 40 years. Most coffee farms are in the vicinity of the household's dwelling. Regarding access to services, households reside about 8, 27, and 55 minutes away from all-weather roads, wet mills (coffee collection centers), and the closest district/woreda capital, respectively (Table 4.1).

Table 4.1. Demographic and socioeconomic characteristics of sample households

Household characteristic	Overall mean (SE)	2019-cohort mean (SE)	2020-cohort mean (SE)
Age of household head (in completed years)	43.84 (0.308)	43.60 (0.432)	44.08 (0.439)
Head has attended elementary education (1=yes)	0.59 (0.011)	0.62 (0.016)	0.57 (0.016)
Head has attended secondary education or higher (1=yes)	0.16 (0.008)	0.18 (0.013)	0.14 (0.011)
Number of household members	5.49 (0.044)	5.30 (0.061)	5.69 (0.064)
Household is member of a cooperative (1=yes)	0.40 (0.011)	0.54 (0.016)	0.26 (0.014)
Livestock owned (in TLU)	1.92 (0.037)	1.94 (0.051)	1.91 (0.054)
Durable asset owned (in PCA)	0.00 (0.042)	0.00 (0.062)	-0.01 (0.057)
Average age of trees in years (in completed years)	19.45 (0.260)	20.89 (0.366)	17.97 (0.362)
Area of total farm (in hectares)	0.78 (0.015)	0.87 (0.021)	0.69 (0.022)
Area of coffee farm (in hectares)	0.33 (0.009)	0.38 (0.013)	0.28 (0.011)
Area of Best Practice (BP) coffee plot (in hectares)	0.23 (0.006)	0.28 (0.010)	0.18 (0.006)
Number of coffee trees on plot	453.18 (14.427)	481.08 (19.256)	424.69 (21.501)
Distance to a mill that collects coffee (in minutes)	27.72 (0.528)	28.45 (0.816)	26.97 (0.667)
Distance to all-weather road (in minutes)	8.13 (0.221)	8.30 (0.344)	7.95 (0.276)
Distance to woreda capital (in minutes)	54.98 43.84	55.28 43.60	54.68 44.08

Source: Sidama coffee program endline surveys collected in April 2021 (2019-cohort) and June 2023 (2020-cohort).
Note: TLU refers to Tropical Livestock Units; PCA refers to principal component analysis; SE is standard error.

4.2. Project participation

Sensitization and sign-up

The qualitative narratives collected indicate that the sensitization process covered all kebeles in the target program woredas and the sign-up (the process for expression of interest) was perceived as largely fair and inclusive, with most of the coffee-producing households that expressed interest in the program able to register in the sign-up form. Most farmers who took part in the key informant interviews and FGDs indicated that they heard about TNS's coffee agronomy program in the mobilization meeting and through their development group leader. For farmer mobilization/sign-up, the program used preexisting development groups (*hiwas*) that were organized or formed by the local/kebele administration. The groups are a semi-formal local administrative structure within each kebele that comprise about 25–30 farm households, on average, and serve as a grassroots forum to discuss local development issues. In a few cases, the groups were reorganized into two or three whenever the number of group members was larger than 30 farm households to facilitate active participation in training sessions.

A total of 56,855 coffee-growing households (33,441 in the 2019-cohort and 26,414 in the 2020-cohort) signed up for (expressed interest in) the program. The vast majority (~90 percent) were registered during the farmer mobilization/sensitization before the start of the program. The remainder were registered after the sensitization (before the baseline) by a team of survey enumerators to ensure that all coffee-growing households in the target woredas were part of the program (mainly to include those that missed the mobilization/sign-up meeting due to other priorities). The project monitoring data (scorecard) indicates that 47,759 households (24,718 in the 2019-cohort and 23,041 in the 2020-cohort) were registered and took part in the program. (Within these households, the program reached 76,377 individual farmers: 39,019 in the 2019-cohort and 37,358 in the 2020-cohort.)

The main motivation for joining the program was the prospect of addressing the main challenges they faced in coffee production, which includes unattractive coffee prices, old coffee trees with low and diminishing productivity, inadequate access to improved coffee seedlings, pests and diseases, and weather/climate variability.

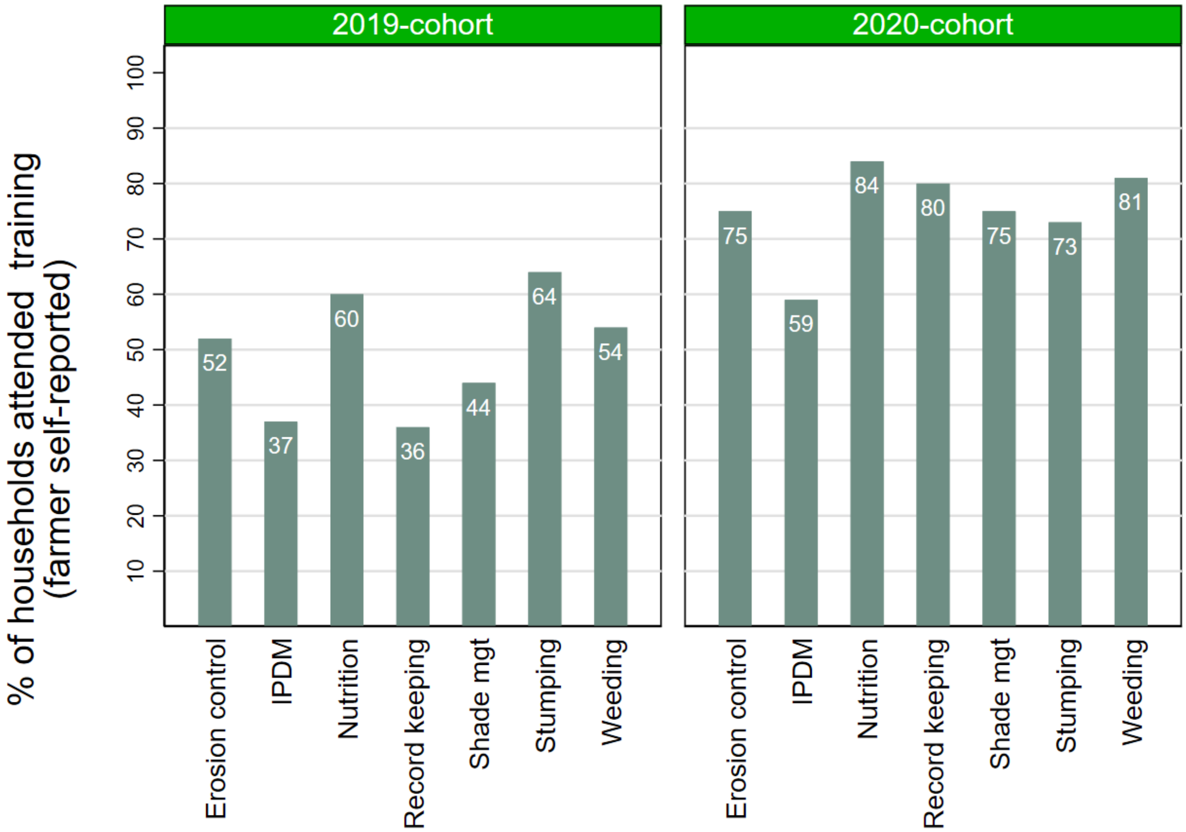
Participation in training

The CFC program comprised 10 topic-specific lesson plans or training modules that were delivered following the coffee production calendar (for example, training on rejuvenation during the stumping season of January–March). In this evaluation we focus on the seven key topics or best practices (that is, rejuvenation, coffee nutrition, weeding, IPDM, soil erosion control, shade management, and record keeping). At endline, sample households were asked whether any member of the household took part in the trainings provided by topic and year. A household is considered “topic-trained” if at least one member of the household attended a training on one of the topics during the course of the program. Figure 4.1 presents participation rates by topic and cohort. Overall, households’ participation rates are moderate for the 2019-cohort and reasonably high for the 2020-cohort.[8,9] The higher participation rates in the 2020-cohort could be the result of experience in attracting/encouraging more households to join the trainings. Another reason could be that the importance of coffee in Aleta Chuko (from where about one-half of the 2019-cohort participants originate) is decreasing as coffee farms are replaced with *khat* and pineapple, and attending training on coffee agronomy may not be farmers’ first priority. In fact, our analysis on determinants of training participation indicates that farm households in Dale woreda were more likely to join the training on stumping than households in Aleta Chuko. This implies that targeting woredas where coffee is a priority (cash) crop is imperative to ensure take-up.

[8] Training participation rates estimated at the FFG level indicate a relatively higher reach, ranging from 67 percent (for record keeping) to 85 percent (for coffee nutrition) in the 2019-cohort and from 80 percent (for IPDM management) to 91 percent (for coffee nutrition) in the 2020-cohort.

[9] The program monitoring data indicate that about 83 percent of farmers (or 90 percent of households) attended at least 5 out of the 10 training topics (that is, 32,011 farmers from 22,277 households in the 2019-cohort and 31,145 farmers from 20,125 households in the 2020-cohort).

Figure 4.1. Households' participation in CFC training program, by main training topic



Source: Sidama coffee program endline surveys collected in April 2021 (2019-cohort) and June 2023 (2020-cohort).

Looking at participation rates by training topic, those on coffee nutrition, weeding, and stumping were attended by a higher share of households, whereas trainings on IPDM and record keeping (in the 2019-cohort) were attended by a relatively smaller share. Lower participation in IPDM and record keeping is also corroborated by the qualitative narratives, where farmers indicated that IPDM is not a major concern in their area, and they are not fully convinced of the value of record keeping.

5. Results and discussions

5.1. Impact of the program on best practices adoption

In this subsection, we present and discuss the impact of the coffee agronomy program on adoption of best practices based on the analysis of the main baseline and endline surveys and stumping surveys (for adoption rate and intensity of stumping). While the results show both the before-and-after and DID estimates, our discussions are mainly based on the latter since the former is subject to a strong assumption that may not hold for most of our key outcomes of interest (as discussed earlier). We used the baseline value for the before-and-after and the endline value of the non-topic-trained for the DID as the outcome of the comparison group. These values are reported in Appendix Table A.3 and under Figures 5.1–5.9 below. Appendix Figure A.5 presents an overview of the estimated treatment effects on adoption of best practices.

Impact on adoption of coffee nutrition

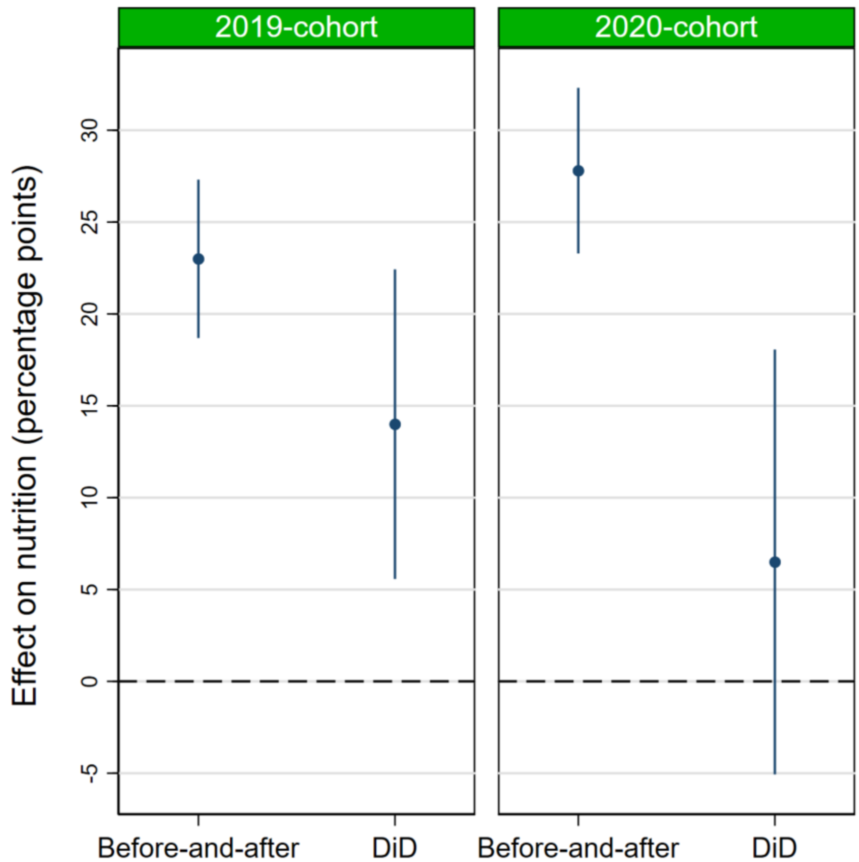
Coffee nutrition is one of the key best practices promoted by the program to ensure continuous replenishment of soil nutrients that may be lost through tissue formation, yields, leaching, or erosion. Given that most coffee areas in Ethiopia are endowed with good-quality soil with limited need for micronutrients or soil correction, and since the use of chemical fertilizer is limited (prohibited) (Teketay 1998), the main soil input promoted by the program on coffee farms is compost or composted manure.

The nutritional status of a coffee farm is assessed by observation of nutrient deficiency symptoms on the leaves and the use of compost or manure both at baseline and endline. A household is considered an adopter of coffee nutrition practice if nearly all coffee leaves on its visited coffee farm (called here a reference plot) are dark green (only less than 5 percent of the leaves can show deficiencies) and if the household applied at least one organic soil input during the production season prior to the survey. Given that compost production and use is seasonal, the use of compost or manure was verified by looking at a compost heap, pit (albeit less recommended), or pile of manure as evidence of composting.

The results point to a clear and meaningful impact of the program on coffee nutrition for the 2019-cohort. The program improved adoption of coffee nutrition inputs (compost or composted manure) by 14 percentage points (based on a matched DID estimate that compares and contrasts topic-trained households with untrained households before and after the intervention; Figure 5.1). This translates into a 21 percent increase in the mean adoption rate of coffee nutrition by topic-trained households as compared to untrained households. (The estimates based on the before-and-after comparison are relatively higher—a 23 percentage point or 40 percent increase in the adoption of coffee nutrition—but again it did not account for potential changes due to natural courses in the program's absence.)

Adoption of coffee nutrition by sample households in the 2020-cohort is positive (an increase of 6.5 percentage points) but not statistically significant. Limited program impact in the 2020-cohort is mainly explained by a considerable increase in the adoption rate of coffee nutrition by both topic-trained and untrained households, presumably due to a positive spillover effect. While adoption of coffee nutrition by topic-trained households increases from 43 percent (baseline) to 75 percent (endline), comparable change is observed among untrained households (from 40 percent at baseline to 64 percent at endline). Yet the observed positive uptake of composting will only provide a meaningful yield effect if implemented at scale by households. Unfortunately, no data on the number of compost heaps, as a proxy for adoption intensity, have been collected.

Figure 5.1. Estimates of treatment effects on adoption of coffee nutrition, by cohort



Source: Sidama coffee program baseline and endline surveys collected in April 2021 (2019-cohort) and June 2023 (2020-cohort).
Note: For the 2019-cohort, the adoption rate of coffee nutrition at baseline was 57 percent and the adoption rate of untrained households was 66 percent. For the 2020-cohort, the adoption rate of coffee nutrition at baseline was 42 percent and the adoption rate of untrained households was 64 percent.

The qualitative narratives corroborate the positive impact of the program on adoption of compost or composted manure on coffee farms. In particular, participants indicated that the program trained them on the recommended ingredients for producing high-quality compost and enabled them to modernize their compost preparation techniques (for example, preparing compost on ground surface as opposed to in holes for ease of management). However, participants indicated that compost preparation, transportation, and application is cumbersome, and they mostly applied it on newly planted and stumped coffee trees. Applying compost on all coffee trees is reportedly difficult, again due to the labor requirement and the amount of compost needed to cover an entire farm. We also observed that adopting compost or composted manure is much harder for female-headed households with limited family labor.

> *"I have prepared compost once during the training and realized that it is a labor-intensive activity. I have no intention of preparing compost in the future because of its labor requirement."* Female in-depth case study participant.

Overall, while adoption rates of coffee nutrition practices by topic-trained households are positive and encouraging, an information or evidence gap remains on the intensity of adoption (that is, share of coffee areas or trees treated with compost or manure), an indicator that is more relevant in terms of understanding the effects of composting on coffee tree productivity.

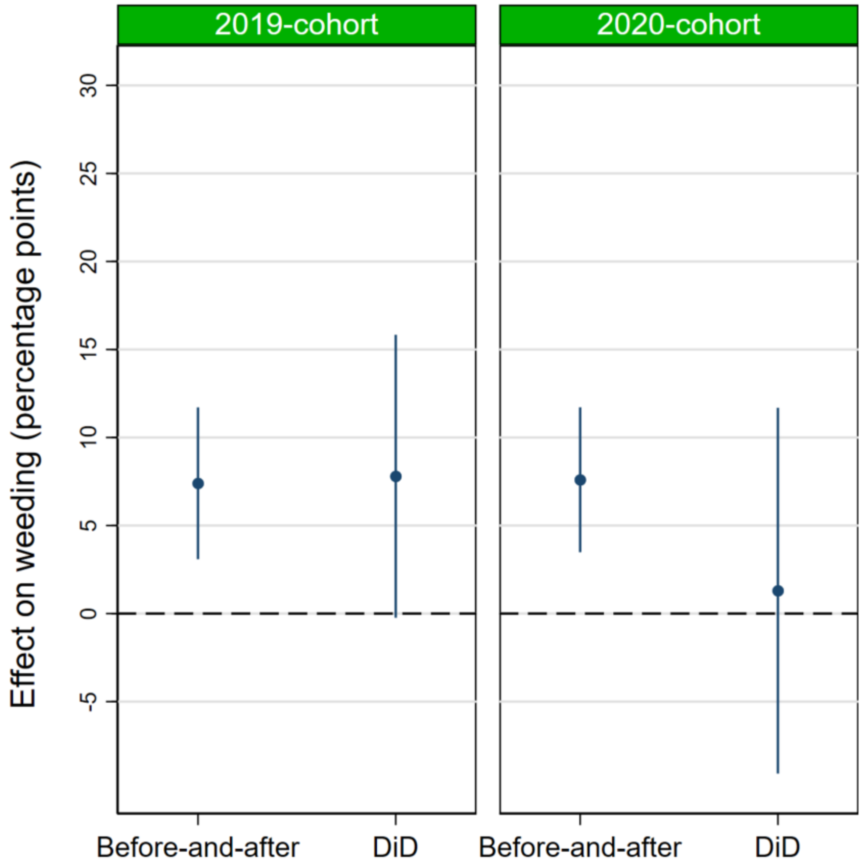
Impact on adoption of weeding

Weeding is another best practice promoted by the program to keep coffee farms weed-free and thereby increase yield. Most coffee-growing areas of Ethiopia (including Sidama) receive ample rainfall and are temperate, a climate suitable for the growth of diverse weed flora. If allowed to grow in coffee areas, weeds can seriously affect yield, since they aggressively compete with coffee trees for soil moisture, nutrients, and sunlight (Eshetu and Kebede 2015). For this reason, the program promotes proactive/frequent weeding as one of the key best practices to control weeds and increase productivity.

The adoption measure for weeding best practice considers several factors, including weeding frequency, presence of weeds, heights, and weeding methods. A household is considered an adopter if: the visited or reference plot is weeded at least twice a year; there are few or no weeds under the tree canopy; any existing weeds are less than 30 centimeters (cm) tall; and the area under the tree canopy has not been dug to clear weeds.[10] Based on this measure, the results indicate that the program improved the adoption of weeding best practices by about 8 percentage points among households that attended the weeding training in the 2019-cohort. This represents a 27 percent increase compared to untrained households, which is meaningful given that weeding is not a new practice for most farmers (Figure 5.2). (The effect based on the before-and-after comparison shows comparable results.) However, the results show no program impact on adoption of the weeding best practice for the 2020-cohort. This is mainly because of comparable changes in the adoption rate of weeding best practices among topic-trained and untrained households, especially in Hawela and Shebedino woredas.

[10] Digging under the tree canopy is not a recommended practice since it can damage the all-important feeder roots, introduce coffee wilt disease, and leave the soil open to erosion.

Figure 5.2. Estimates of treatment effects on adoption of weeding, by cohort



Source: Sidama coffee program baseline and endline surveys collected in April 2021 (2019-cohort) and June 2023 (2020-cohort).
Note: For the 2019-cohort, the adoption rate of weeding at baseline was 25 percent and the adoption rate of untrained households was 29 percent. For the 2020-cohort, the adoption rate of weeding at baseline was 20 percent and the adoption rate of untrained households was 29 percent.

The qualitative evidence indicates that the program is impactful in increasing knowledge about the benefits of proactive/frequent weeding and recommended weeding methods. However, a sizable share of farmers continue to dig under the tree canopy, a practice that is discouraged to prevent root damage and reduce coffee wilt disease and soil erosion. Household members who participated in the discussions indicated that the program was instrumental in terms of creating awareness about the risk of digging under the tree canopy, but many farmers continued digging because clearing weed using hand/sickles or grass hooks is reportedly not effective during the dry season and on fields with compact soil. In fact, digging under the tree canopy reduces the impact of the program on the adoption rate of good weeding practices. For instance, the descriptive statistics from the 2019-cohort show that digging under the tree canopy—observed in about 58 percent of plots—diminished/limited the adoption rate of good weeding practices to one-third of our sample households, even though almost all households reported weeding at least twice a year and about 80 percent of visited plots had no weeds under the tree canopy. The results from the 2020-cohort are similar.[11]

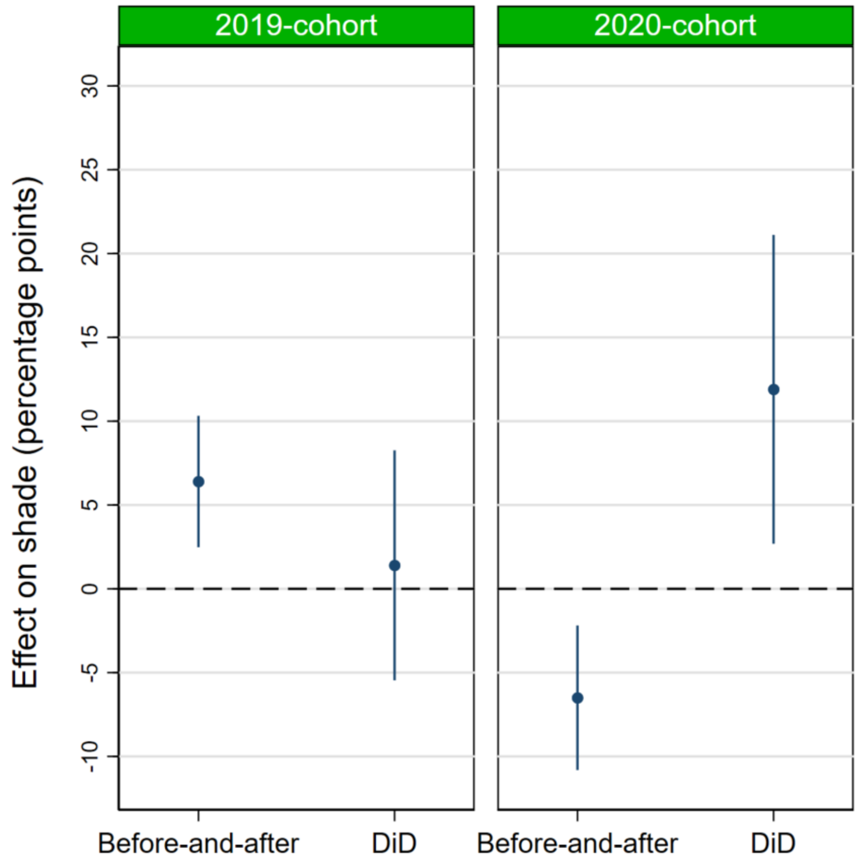
Impact on adoption of shade

The program promoted proper shade management on coffee farms both to improve coffee productivity and quality and to support multiple ecosystem services. Adequate level of shade improves productivity and quality of coffee beans by protecting coffee trees from excessive sunlight, influencing pests, protecting the soil from erosion, building up the soil organic matter and fixing nitrogen, and suppressing weed growth by inhibiting incoming light (Bote and Paul Struik 2011; Alemu 2015; Silva Neto et al. 2018; Karp et al. 2013; Teketay 1998). At the same time, shade-grown coffee provides multiple environmental services, such as climate change adaptation by reducing temperatures (Jha et al. 2014). Shade is specifically important for Arabica coffee, which evolves in the dense forests of western Ethiopia. Experts recommend shade levels of between 20 percent and 40 percent to protect coffee trees from high temperatures and moisture loss. Conversely, very high levels of shade (that is, more than 40 percent) are not recommended since they can reduce yields.

The adoption of shade trees is measured by the estimated share of shade on the visited coffee plot. Households are considered adopters if the estimated shade level is 20 percent or more of the coffee plot or if households planted new shade trees during the course of the program. With this measure, the program had no or limited impact on improving shade management among households that participated in the 2019-cohort (Figure 5.3), for which shade levels were found to be comparable at baseline and endline. The observed marginal impact (in the before-and-after comparison) is mainly driven by an increase in the share of farm households that planted new shade trees (from about 7 percent at baseline to 16 percent at endline). On a positive note, the program improved the adoption of shade management by about 12 percentage points in the 2020-cohort, equivalent to a 46 percent increase in the mean adoption rate of shade management by topic-trained households over untrained households. However, these results should be interpreted with caution since the shade coverage measurement is based on enumerators' observations and subject to measurement error.

[11] While 86 percent of households reported weeding at least twice a year, 27 percent of households had no weeds under the tree canopy, and only 3 percent of the plots had weeds taller than 30 cm, the adoption rate of good weeding practices in the 2020-cohort was 28 percent at endline due to digging under the tree canopy by 50 percent of sample households.

Figure 5.3. Estimates of treatment effects on adoption of shade management, by cohort



Source: Sidama coffee program baseline and endline surveys collected in April 2021 (2019-cohort) and June 2023 (2020-cohort).
Note: For the 2019-cohort, the adoption rate of shade management at baseline was 18 percent and the adoption rate of untrained households was 29 percent. For the 2020-cohort, the adoption rate of shade management at baseline was 47 percent and the adoption rate of untrained households was 26 percent.

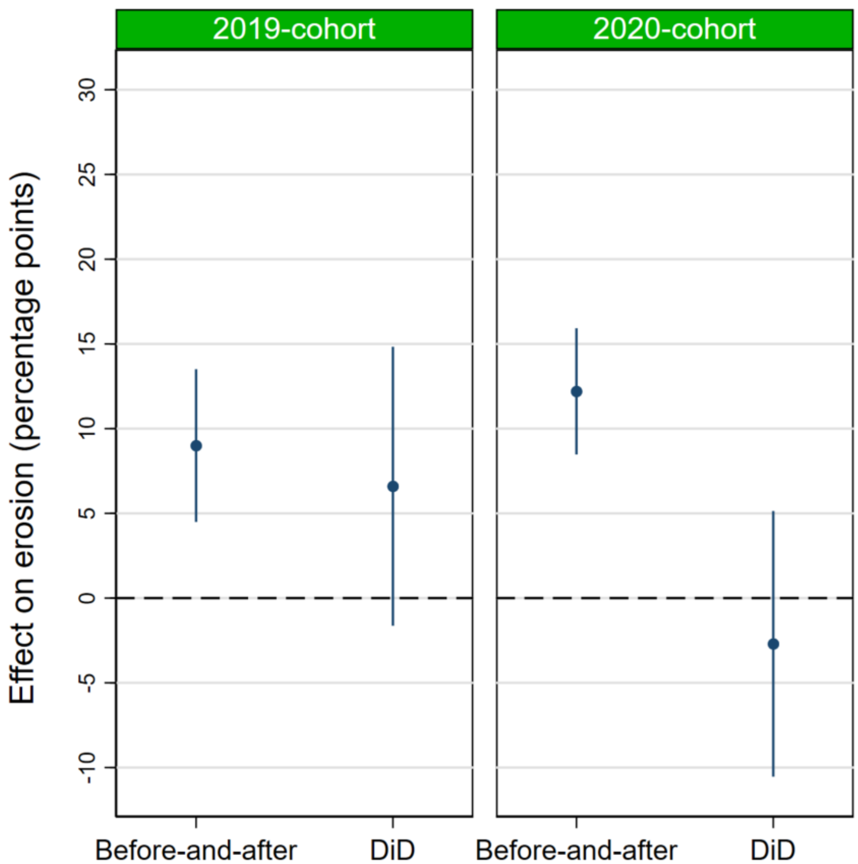
The qualitative narratives indicate that farmers already had knowledge on the importance of growing/maintaining shade trees on coffee fields before the program. The training was instrumental in educating farmers on shade tree varieties that are suitable for coffee fields and encouraging farmers to intentionally plan new shade trees and maintain the recommended coverage (20–40 percent of the coffee area). Most households visited as part of the qualitative case studies had already started planting new shade trees recommended by the program, even though most of these visited plots had an estimated shade coverage of more than 40 percent.

Impact on adoption of soil erosion control

Soil erosion is a serious problem in Ethiopia and studies have indicated that soil loss and the consequent sedimentation distress a substantial share of agricultural land in the country (Sonneveld, Keyzer, and Albersen 1999 Bekele and Drake 2003). Coffee areas, especially those with a plateau landscape and those that receive heavy rains, are subject to erosion. Soil erosion causes loss of topsoil and degrades coffee farms' soil fertility, but also leaves roots exposed, ultimately affecting production and productivity.

The program promoted a wide range of soil erosion control methods suitable for different farm landscapes, and a farm household is considered an adopter if it used at least one of the soil erosion control methods on the reference plot. Based on this measurement, the results suggest that the program increased adoption of at least one soil erosion control method on the reference plot by 7 percentage points for the 2019-cohort. This improvement translates to a 24 percent increase among topic-trained households as compared to untrained households (Figure 5.4). While the results do not show any overall treatment effect for topic-trained households in the 2020-cohort, the analysis where the slope of the farm is interacted with training participation shows that the training had a significant impact on topic-trained households with a steep coffee farm.[12]

Figure 5.4. Estimates of treatment effects on soil erosion control, by cohort



Source: Sidama coffee program baseline and endline surveys collected in April 2021 (2019-cohort) and June 2023 (2020-cohort).
Note: For the 2019-cohort, the adoption rate of soil erosion control at baseline was 25 percent and the adoption rate of untrained households was 28 percent. For the 2020-cohort, the adoption rate of soil erosion control at baseline was 12 percent and the adoption rate of untrained households was 22 percent.

[12] The adoption rate of at least one soil erosion control method is 24 percent on coffee plots that are steep, versus 17 percent on flat plots and 15 percent on medium-steep plots.

Similarly, the qualitative evidence indicates variations in the adoption of soil erosion control across program woredas that are mainly explained by differences in the topography of coffee farms. For instance, Bona Zuria woreda is mostly a highland area with high rainfall, and trained households visited during the qualitative survey adopted/employed soil erosion methods such as terracing and planting grasses (which are also used for animal feed). Conversely, soil erosion is reportedly not a concern for households in Aleta Chuko and most of the households visited do not practice soil erosion control.

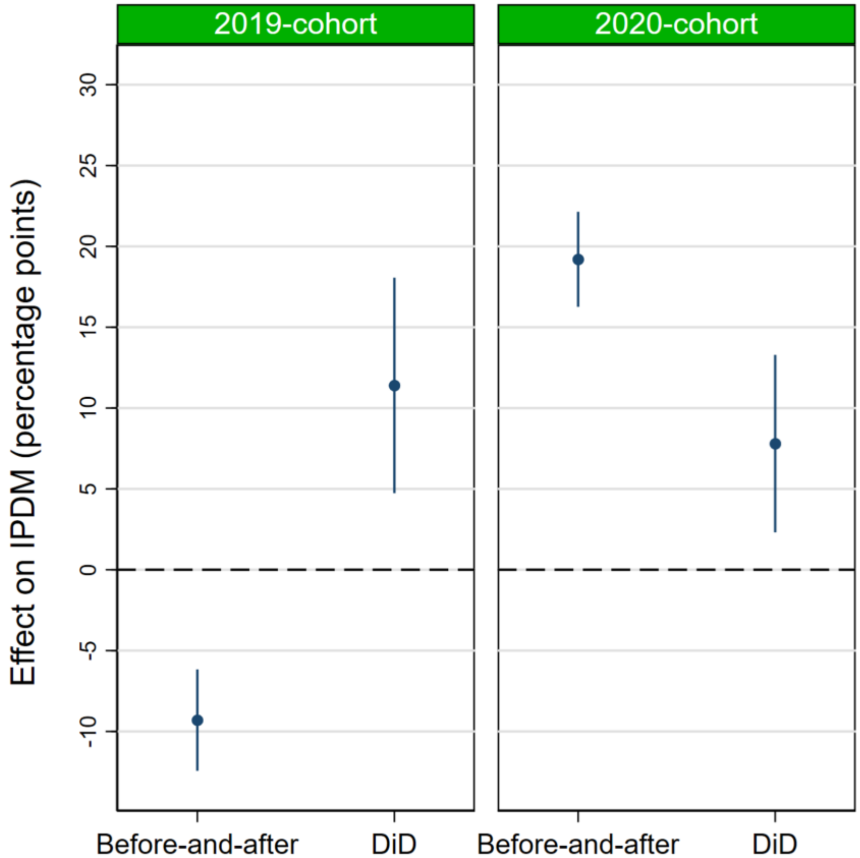
Impact on adoption of IPDM

Coffee pests (for example, coffee berry borer, leaf miners, antestia) and diseases (for example, coffee berry disease (CBD), coffee wilt disease, coffee leaf rust) can result in severe yield loss and quality deterioration if not properly and timely controlled. The Sidama coffee program promoted a wide range of pest and disease control methods that coffee farmers could practice to avoid or reduce the occurrence of pests and diseases. The methods promoted by the program included genetic control (for example, planting a seedling resistant to CBD) and better farm management practices (for example, pruning or keeping canopy open to control CBD, or stumping to reduce egg-laying sites to control the white stem borer).

We measure "adoption" of IPDM through farm households' reported knowledge of methods to control common pests and diseases, since IPDM cannot be observed in real time, and farmers only need to practice the method when an infestation occurs (with the exception of prevention methods). In other words, we measure farm households' knowledge on IPDM methods with the assumption that farmers with such knowledge will practice the methods to prevent or control pest and disease occurrence. With this measure, the results show improvements in IPDM knowledge among topic-trained households in both the 2019- and 2020-cohorts. Specifically, the program improved knowledge on IPDM methods by 11 and 8 percentage points among topic-trained households in the 2019- and 2020-cohorts, respectively (Figure 5.5). These represent an increase in IPDM knowledge among trained households by close to twofold in the 2019-cohort and 50 percent in the 2020-cohort compared to untrained households.

The qualitative narrative supports the findings that topic-trained households are knowledgeable in pest and disease prevention and in control methods. Participants of the qualitative case studies indicated that after the training they regularly inspected their coffee farms for pests and diseases and took swift action if they observed their occurrence. While most households reported that pests and diseases are not a major concern in their area, uprooting infected coffee trees is the most common control method they practice when an infestation occurs. After the training they also practiced biological pest and disease prevention and control measures, for instance, by avoiding harming chameleons, which can be instrumental in controlling pests.

Figure 5.5. Estimates of treatment effects on IPDM, by cohort

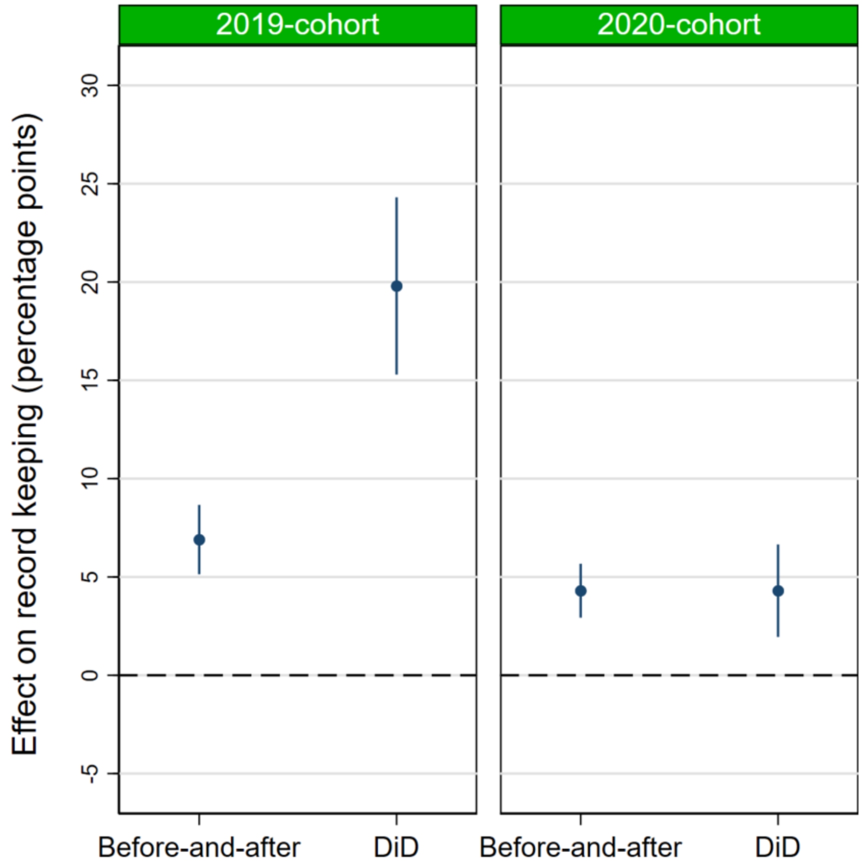


Source: Sidama coffee program baseline and endline surveys collected in April 2021 (2019-cohort) and June 2023 (2020-cohort).
Note: For the 2019-cohort, the adoption rate of IPDM control at baseline was 19 percent and the adoption rate of untrained households was 6 percent. For the 2020-cohort, the adoption rate of IPDM control at baseline was 2 percent and the adoption rate of untrained households was 16 percent.

Impact on adoption of record keeping (and business skills)

Besides farm management practices, the program trained households in business skills, such as financial record keeping. Most rural farm households in Ethiopia (including in Sidama) rarely keep financial records to track farm expenses, incomes, and returns. For instance, only one household was able to show any expense or income records at baseline in both the 2019- and 2020-cohorts. While the results show an improvement in adoption of record keeping among topic-trained households as compared to their counterparts (by about 20 percentage points in the 2019-cohort and 5 percentage points in the 2020-cohort), the share of households that passed the record keeping best practice level at endline was still very small in absolute terms. The qualitative evidence indicates that farmers with low literacy and numeracy levels were less interested in keeping records and those with more education were not fully convinced of its value.

Figure 5.6. Estimates of treatment effects on record keeping, by cohort



Source: Sidama coffee program baseline and endline surveys collected in April 2021 (2019-cohort) and June 2023 (2020-cohort).
Note: For the 2019-cohort, the adoption rate of record keeping at baseline was 0.1 percent and the adoption rate of untrained households was 0.7 percent. For the 2020-cohort, the adoption rate of record keeping at baseline was 0.1 percent and the adoption rate of untrained households was 1.0 percent.

Impact on adoption of rejuvenation/stumping

Coffee rejuvenation (stumping) is the key best practice promoted by the program and is new for most farmers in the area. It involves properly cutting old and unproductive coffee trees at their base for a complete renewal, resulting in increased quantity and quality of coffee harvest after two to three years. Most coffee trees grown in Ethiopia were planted over two to three decades ago and these trees are currently producing coffee from unproductive main stems (Minten et al. 2019). For instance, the average age of coffee trees owned by households in our sample of 2019- and 2020-cohorts was 21 and 18 years at baseline, respectively (Table 4.1) and farmers had rarely been taught how to rejuvenate their coffee trees to improve their yields sustainably. The training on rejuvenation taught farm households on the benefit and techniques of stumping. It also trained households on the need to limit the number of main stems on stumped/rejuvenated coffee trees to three to four through sucker selection.[13]

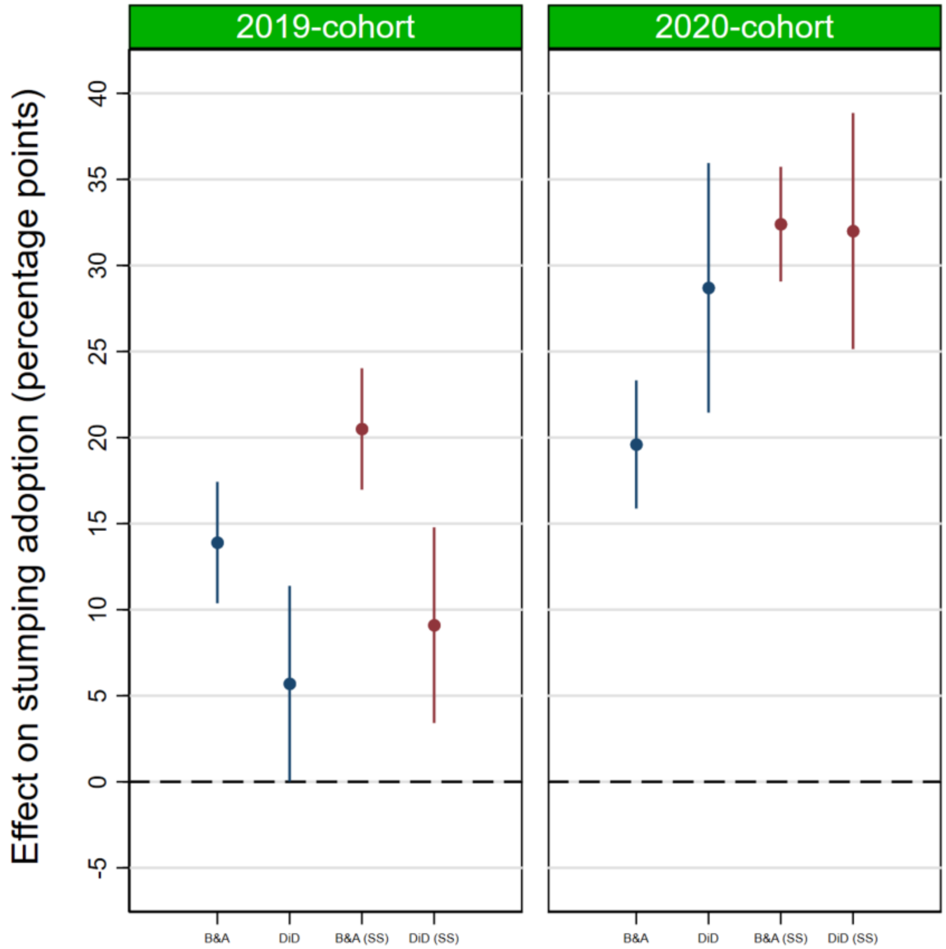
We measure adoption of stumping using two surveys: the main baseline and endline surveys conducted in collaboration with Laterite/TNS and the stumping surveys conducted by IFPRI in collaboration with HWG. In both surveys, we asked sample households whether they had stumped their coffee trees and visited the main (reference) coffee plot where the stumping had taken place (both at baseline and endline). Stumping measurement in the endline survey was based on farmers' self-report and enumerators' observation of the visited plot, whereas in the stumping survey enumerators counted the total number of coffee trees stumped on the reference coffee field and measured the size of the field using GPS devices. The results show a clear and meaningful effect of the rejuvenation training on the adoption of stumping (Figure 5.7). Using data from the two main surveys, we find that topic-trained households in the 2019- and 2020-cohorts are 6 and 29 percentage points more likely to have adopted stumping compared to their nonparticipant counterparts (shown as navy spikes and markers in Figure 5.7). Given that only 12 percent and 14 percent of untrained households adopted stumping at endline in the 2019- and 2020-cohorts, the effect of the rejuvenation training on stumping adoption represents a 48 percent (2019-cohort) and a twofold (2020-cohort) increase over the adoption rate of untrained households. The estimates based on the stumping surveys where we observe and count stumped coffee trees (maroon spikes and markers in Figure 5.7) show a comparable effect: an increase in stumping adoption of 9 percentage points (45 percent over the adoption rate of untrained households) in the 2019-cohort and an increase of 32 percentage points (a twofold increase over the adoption rate of untrained households) in the 2020-cohort.

The results on adoption trends across the three stumping seasons show that a considerable share of the program impact on stumping occurred during the first year. This is plausible since stumping is a relatively new practice and it takes two to three years for farmers to see its impact—and to decide whether to adopt the practice at scale. In fact, our qualitative discussions with farm households in both the 2019- and 2020-cohorts clearly and repeatedly indicated that farmers were convinced of the need to revitalize their coffee trees, especially after observing the new healthy stems grown on stumped trees. At the same time, however, they wanted to see its impact on yield before stumping at scale on a yearly basis.

> *"I stumped only a few trees after the training because I was not sure whether the coffee would regrow and produce more beans. Now, I observed its benefits and plan to stump more coffee trees in the near future".* Male in-depth case study participant (Bona Zuria woreda).

[13] The program also teaches farm households about intercropping stumped coffee plots with recommended crops such as beans and chilies to effectively use the land and provide food or income while the stumped coffee trees rejuvenate.

Figure 5.7. Estimates of treatment effects on stumping, by cohort

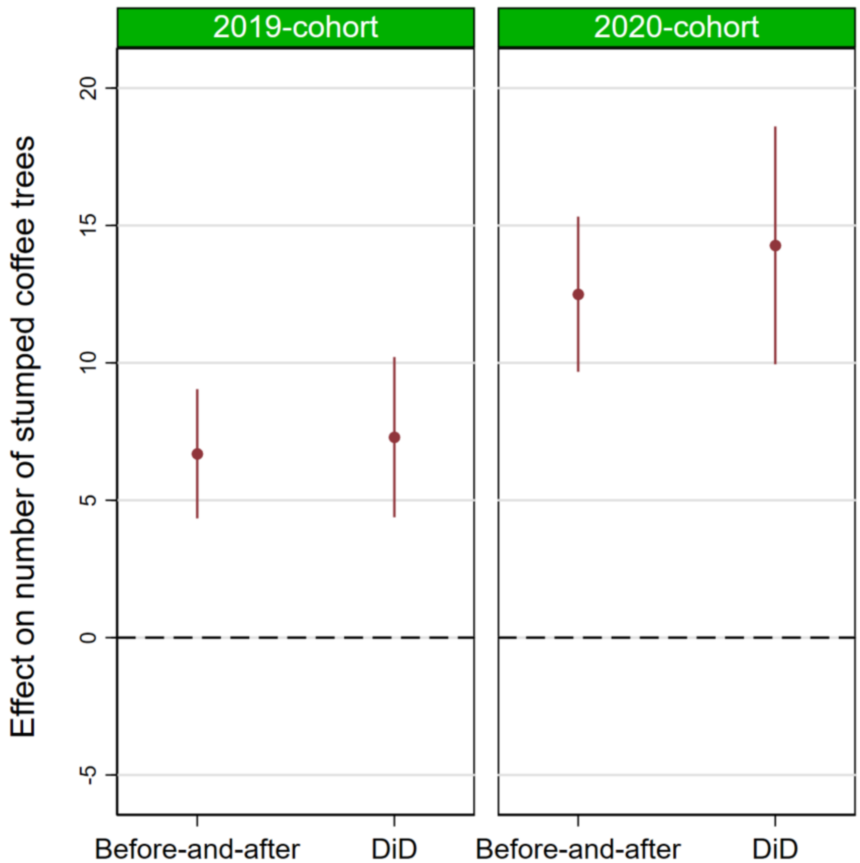


Source: Sidama coffee program baseline and endline surveys collected in April 2021 (2019-cohort) and June 2023 (2020-cohort).

Note: The results shown by navy spikes and markers are based on the baseline and endline data collected in collaboration with Laterite/TNS. The results shown by maroon spikes and markers are based on the stumping baseline and endline surveys. For the 2019-cohort, the adoption rate of stumping at baseline was 4 percent (for both datasets) and the adoption rate of untrained households was 12 percent and 20 percent for the main data and stumping data, respectively. For the 2020-cohort, the adoption rate of stumping at baseline was 16 percent and 6 percent for the main data and stumping data, respectively, and the adoption rate of untrained households was 14 percent and 16 percent for the main data and stumping data, respectively.

Besides adoption rates, the data from the stumping surveys allow us to estimate the impact of the rejuvenation training on the intensity of stumping (the intensive margin) as measured by the number and share of trees stumped on the visited (reference) plots. The number of stumped trees was measured by a direct counting of stumped and unstumped trees by enumerators on the plot where the farmer adopted the practice. The results show clear evidence of the impact on intensity of stumping among topic-trained households in both cohorts (Figure 5.8). Specifically, topic-trained households in the 2019- and 2020-cohorts stumped an average of 7.5 and 14.0 more trees during the course of the rejuvenation training, respectively.[14] This represents a more than threefold increase over the average number of coffee trees stumped by untrained households at endline. Like that of adoption, the impact of the rejuvenation training on the number of stumped coffee trees mainly occurred during the first year (right after the first training) for the same reason mentioned above.

Figure 5.8. Estimates of treatment effects on the number of stumped coffee trees, by cohort



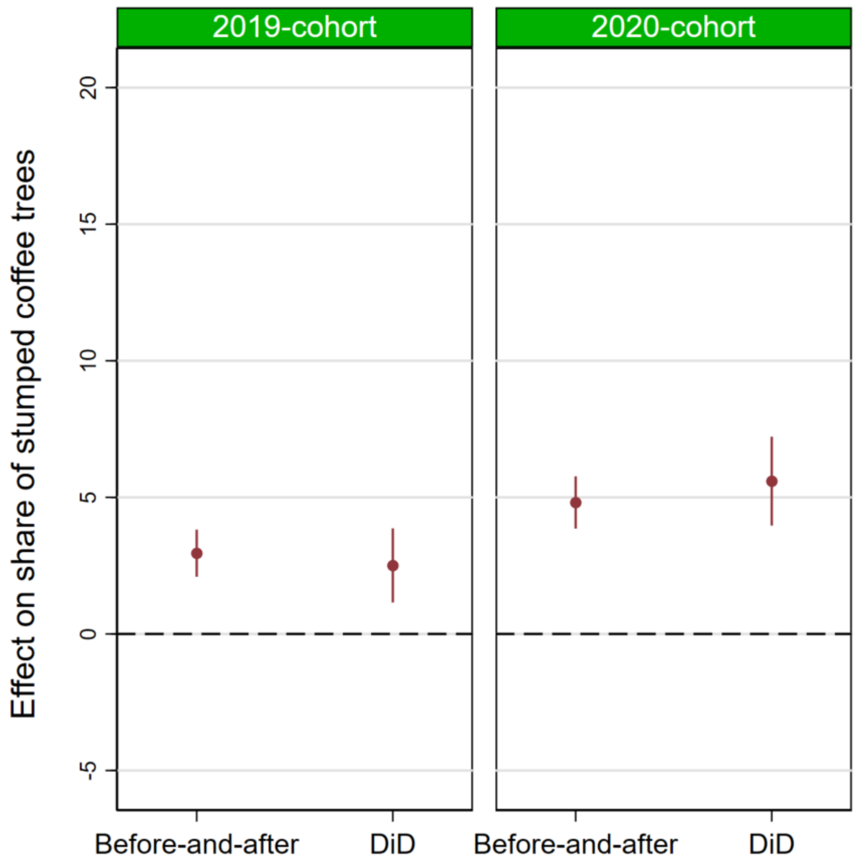
Source: Sidama coffee program baseline and endline surveys collected in April 2021 (2019-cohort) and June 2023 (2020-cohort).
Note: For the 2019-cohort, the number of stumped coffee trees at baseline was 1.2 and the number of stumped coffee trees of untrained households was 2.1 trees, on average. For the 2020-cohort, the number of stumped coffee trees at baseline was 2.1 and the number of stumped coffee trees of untrained households was 4.0 trees, on average.

Figure 5.9 presents the results on the share of stumped coffee trees (that is, the number of coffee trees stumped as a percentage of the total number of coffee trees on the visited (reference) plot). While we observe a positive and statistically significant impact of the rejuvenation training on the share of stumped trees in both cohorts, the magnitudes are rather small. In the 2019-cohort, the average topic-trained household stumped 2.5 percentage points more of its coffee trees on the reference plot during the course of the program than did the average untrained household. Similarly, the impact of the

[14] The average number of stumped coffee trees is higher when the sample is restricted only to topic-trained households (12–18 trees) and trained households that adopt stumping (40–43 trees).

program on the share of stumped coffee trees was limited to 5.5 percentage points in the 2020-cohort. These impacts represent a more than twofold increase over the share of stumped coffee trees by untrained households at endline.

Figure 5.9. Estimates of treatment effects on the share of stumped coffee trees, by cohort



Source: Sidama coffee program baseline and endline surveys collected in April 2021 (2019-cohort) and June 2023 (2020-cohort).
Note: For the 2019-cohort, the share of stumped coffee trees at baseline was 0.6 percent and the share of stumped coffee trees by untrained households was 2.0 percent. For the 2020-cohort, the share of stumped coffee trees at baseline was 1 percent and the share of stumped coffee trees of untrained households was 2 percent.

While the relative increase in stumping intensity is large (due to a low baseline), it is still small in absolute terms. The program recommended that farmers stump about 20 percent of their older/unproductive trees every year, but farmers who adopted the practice stumped a much smaller number and share of their coffee trees. As mentioned above, the qualitative narratives indicate that farmers wanted to learn about the yield gain of stumping through experimentation before scaling up. They also mentioned that the production loss for about two to three seasons after stumping is one of the main reasons discouraging them from implementing stumping at scale. Some participants indicated that not all coffee trees on their plots were eligible for stumping; for example, trees that were planted in the last 10 years or so.

It is worth mentioning that our basic estimate of the number and share of stumped coffees may underestimate the impact of the training program for two reasons. First, the outcome variable includes nonadopters (who are topic-trained), and this tends to attenuate the parameter estimates downward. For example, the average number of stumped trees by those topic-trained at the endline, among those who did stump (that is, those with nonzero stumped trees), is 36–41, or about 7–8 percent of the average number of coffee trees in the visited (reference) plot. Second, our estimation only considers the visited (reference) coffee plot. While this is the main plot where the stumping took place, it is not the only plot owned by sample households. For instance, about one-third of sample households in the 2020-cohort with multiple coffee plots self-reported stumping on plots other than the reference plot. Consistent with the main results based on the reference (visited) plots, adoption and intensity of stumping on other plots is significantly higher among topic-trained than untrained households (see Appendix Table A.4).

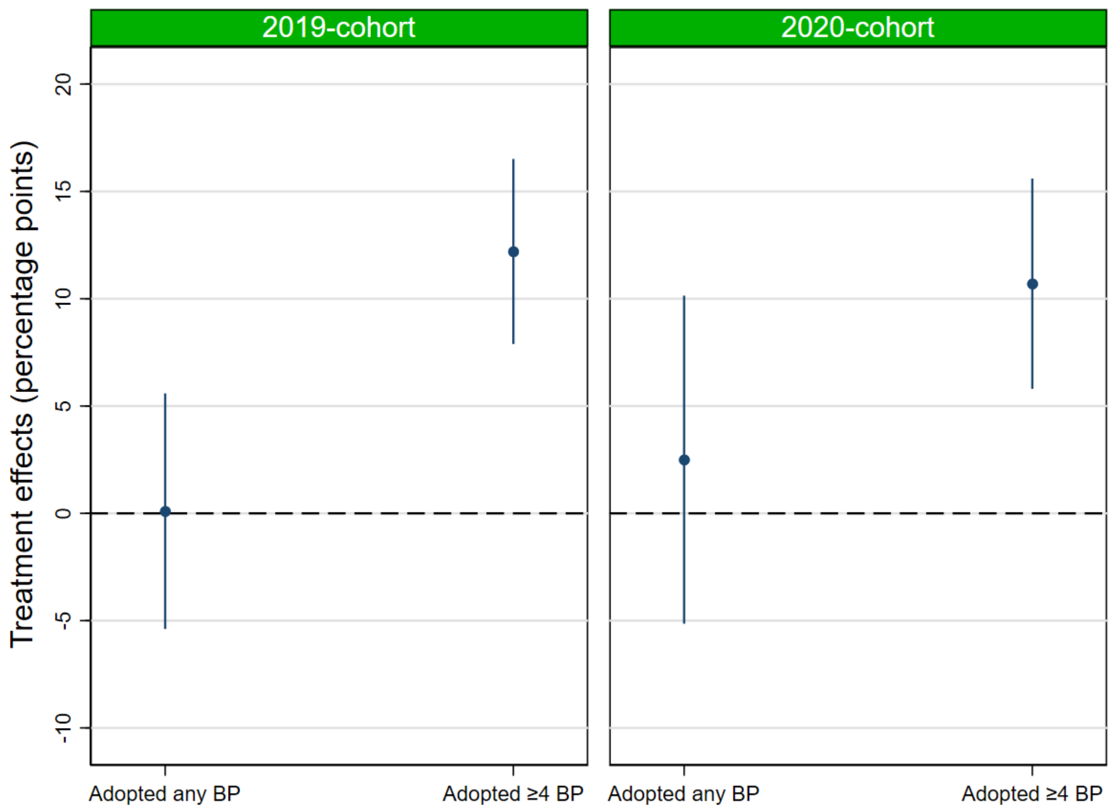
We conducted a subsample analysis to formally test some of the above qualitative insights on rate and intensity of stumping adoption. First, we estimate the impact by scale of operation (that is, number of coffee plots, coffee area, number of coffee trees) to check whether households with larger plots or more coffee area and trees adopt stumping more intensively since they can afford experimentation and have more (stumping) capacity relative to households with small farms. Overall, the results show that farm households with more than one coffee plot and larger coffee area and number of coffee trees are more likely to adopt stumping and stump relatively larger number of coffee trees (Appendix Figures A.1–A.3). Second, we estimate impact heterogeneity by the age of coffee trees to test whether households with older coffee trees are more likely to adopt stumping more intensively. While the results on the likelihood of adoption do not show much difference, stumping intensity among households with coffee trees older than 15 years is much higher than that of coffee trees less than 15 years (Appendix Figures A.1–A.3).

We also estimate the impact of the coffee agronomy training program on the number of best practices adopted based on an alternative definition of training participation used by the program implementer (TNS). According to this definition, a farmer is considered “trained” if s/he attended at least 50 percent of the training topics. Following this definition, we consider a household trained if s/he reports attendance in at least four of the seven key training topics considered in this evaluation. With this definition, 50 percent and 80 percent of the sample households were trained in the 2019- and 2020-cohorts, respectively.

Figure 5.10 presents the effects of attending at least 50 percent of the key training topics on the adoption of any practice and on four or more practices. The results clearly show that trained households are about 12 percentage points more likely to adopt four or more practices compared to those who attended less than one-half of the training topics in the 2019-cohort. Given that only 3 percent of the “untrained” households adopted four or more practices in the 2019-cohort, the effect of the training on adoption of four or more practices represents a threefold increase over the adoption rate of untrained households. The results from the 2020-cohort are comparable: trained households are about 11 percentage points more likely to adopt four or more practices compared to those who attended less than one-half of the training topics, a twofold increase over the adoption rate of untrained households

(5 percent). We also find that trained farmers adopt a relatively greater number of practices in both cohorts: on average, trained households adopt 0.4 to 0.5 more practices, or a 22–30 percent increase, compared to the ~1.8 number of practices adopted by untrained households (Appendix Table A.10).

Figure 5.10. Estimates of treatment effects on the number of best practices adopted, by cohort



Source: Sidama coffee program baseline and endline surveys collected in April 2021 (2019-cohort) and June 2023 (2020-cohort).
Note: BP refers to best practices.

5.2. Pathways (mechanisms)

To understand the mechanisms through which the above results were realized, we examine a set of intermediate outcomes (that is, knowledge, access to tools). Table 5.1 presents the results of the effect of the CFC training program on farm households' knowledge of best practices, measured as binary variables, with a value of one indicating that the respondent provided correct answers to questions assessing their familiarity with the recommended best practices, and zero otherwise. Appendix Table A.1 the presents the survey questions covering the seven best practices assessed in this report alongside the correct answer(s).

The results from the 2019-cohort clearly indicate that participation in trainings significantly improved farmers' knowledge of best practices, except in the case of shade and soil erosion control (practices that are not new for most coffee-producing households in Ethiopia). While relatively large impacts are observed in IPDM (8 percentage points) and record keeping (6 percentage points), the training also improved knowledge in coffee nutrition (2 percentage points), weeding (3 percentage points), and stumping (2 percentage points) among topic-trained households. In the 2020-cohort, however, the impacts of the training on knowledge improvements are limited to coffee nutrition (5 percentage points) and IPDM (4 percentage points). The results for any training and at least three trainings indicate a comparable impact on farmers' overall knowledge (Appendix Table A.5).

Table 5.1. Estimates of treatment effects on knowledge of best practices, by cohort (before-and-after comparison)

	Knowledge						
	Coffee nutrition	Weeding	Shade	Erosion control	IPDM	Record keeping	Stumping
2019-cohort							
Attended training (yes=1)	0.022**	0.034**	0.002	0.001	0.082***	0.063***	0.023*
	(0.010)	(0.015)	(0.016)	(0.012)	(0.018)	(0.021)	(0.013)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.672***	0.562***	0.462***	0.613***	0.094	0.605***	0.816***
	(0.091)	(0.129)	(0.141)	(0.102)	(0.123)	(0.170)	(0.097)
Untrained mean	0.935	0.860	0.848	0.869	0.121	0.293	0.922
Obs.	1,840	1,843	1,845	1,888	1,892	1,752	1,479
R2	0.053	0.038	0.031	0.214	0.051	0.155	0.066
Adjusted R2	0.045	0.030	0.023	0.208	0.043	0.148	0.056
2020-cohort							
Attended training (yes=1)	0.053***	0.002	-0.005	-0.014	0.046***	0.033	0.007
	(0.020)	(0.016)	(0.008)	(0.013)	(0.015)	(0.026)	(0.009)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.529***	0.423***	0.843***	0.881***	-0.146	0.482**	0.843***
	(0.135)	(0.135)	(0.089)	(0.096)	(0.129)	(0.191)	(0.087)
Untrained mean	0.840	0.919	0.972	0.944	0.087	0.285	0.971
Obs.	1,864	1,862	1,864	1,860	1,864	1,864	1,804
R2	0.098	0.084	0.035	0.056	0.040	0.116	0.038
Adjusted R2	0.090	0.076	0.027	0.047	0.031	0.108	0.029

Source: Sidama coffee program baseline and endline surveys collected in April 2021 (2019-cohort) and June 2023 (2020-cohort).
Note: Control variables include household demographics (household head age and education, household size); assets (land, livestock, durables); coffee farm characteristics (coffee area, number and age of coffee trees); access to services measured through distance to mill, road, and woreda center; and membership in a cooperative. Untrained mean refers to the average knowledge score of sample households that are not topic trained.

The small magnitude of impact in the 2019-cohort and the limited impact in the 2020-cohort partly results from the nature of the knowledge questions, which asked about farmers' awareness of best practices instead of technical questions such as at what height and angle a coffee tree should be stumped. As a result, most untrained households were also able to answer such simple awareness questions (see the untrained mean in Table 5.1). Untrained households could also hear about the practice from trained households or become aware of a given best practice during a training session on another topic when content was recapped and/or during farm visits.

Next, we estimate the correlation between knowledge and adoption of best practices to test a key assumption in the program's ToC, which partly associates limited adoption of best practices to knowledge gaps. The results show a significant correlation between knowledge and adoption for most practices in both cohorts, except for shade (again, a practice known by most farmers before the program). For instance, farm households that are knowledgeable on coffee nutrition are 36–37 percentage points more likely to adopt the practices than their counterparts. Similarly, significant correlations are observed between knowledge and adoption for erosion control, record keeping, and stumping in both cohorts (Table 5.2). The estimates based on farmers' overall knowledge indicate a statistically significant association between knowledge and adoption of best practices. In particular, farmers with higher overall knowledge tend to adopt a relatively large number of best practices (Appendix Table A.5).

Table 5.2. Correlation between knowledge and adoption of best practice, by cohort

	Adoption					
	Coffee nutrition	Weeding	Shade	Erosion control	Record keeping	Stumping
2019-cohort						
Knowledge on subject practice (yes=1)	0.358*** (0.053)	0.069** (0.031)	0.000 (0.026)	0.199*** (0.031)	0.051*** (0.012)	0.046** (0.022)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-0.247 (0.167)	0.208 (0.168)	-0.236 (0.151)	0.131 (0.161)	-0.113* (0.066)	-0.294** (0.117)
Mean of less knowledgeable	0.354	0.251	0.186	0.091	0.017	0.043
Obs.	1,840	1,843	1,845	1,888	1,817	1,841
R2	0.119	0.055	0.048	0.057	0.035	0.035
Adjusted R2	0.111	0.047	0.040	0.049	0.027	0.027
2020-cohort						
Knowledge on subject practice (yes=1)	0.372*** (0.031)	0.024 (0.034)	-0.038 (0.068)	0.167*** (0.021)	0.015* (0.008)	0.181*** (0.033)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.268 (0.201)	0.321* (0.181)	0.829*** (0.218)	-0.031 (0.157)	-0.072 (0.055)	-0.670*** (0.175)
Mean of less knowledgeable	0.231	0.235	0.527	0.030	0.017	0.052
Obs.	1,864	1,862	1,864	1,860	1,864	1,862
R2	0.124	0.025	0.115	0.039	0.020	0.042
Adjusted R2	0.116	0.016	0.106	0.030	0.011	0.033

Source: Sidama coffee program baseline and endline surveys collected in April 2021 (2019-cohort) and June 2023 (2020-cohort).
Note: Control variables include household demographics (household head age and education, household size); assets (land, livestock, durables); coffee farm characteristics (coffee area, number and age of coffee trees); access to services measured through distance to mill, road, and woreda center; and membership in a cooperative. Mean of less knowledgeable refers to the adoption rate of a best practice by those households that did not demonstrate adequate knowledge on that given practice.

As indicated in Section 2, the program introduced tools necessary for experiential learning and (proper) adoption of key best practices. To encourage widespread adoption, it facilitated farmers' access to the required tools through their respective FTs and Focal farmers. Table 5.3 presents results on the effects of getting access to saws and wheelbarrows on adoption of stumping and coffee nutrition, respectively. The results show a significant association between access to a stumping saw and stumping adoption. For instance, in the 2019-cohort, access to a stumping saw increased adoption of stumping by about 7 percentage points, a 100 percent increase over the adoption rate of households without access to a stumping saw. Similarly, access to tools increased the likelihood of stumping adoption by 8 percentage points in the 2020-cohort. However, access to a wheelbarrow does not have any statistically distinguishable effect on adoption of coffee nutrition (Table 5.3). (We also estimated the interaction between stumping knowledge and access to tools and the results show no interaction effect.)

Table 5.3. Correlation between access to tools and adoption of best practice, by cohort

	Adoption	
	Stumping	Coffee nutrition
2019-cohort		
Access to stumping saw (yes=1)	0.068***	
	(0.015)	
Access to wheelbarrow (yes=1)		
Control variables	Yes	
Constant	-0.266**	
	(0.113)	
Comparison mean	0.067	
Obs.	1,900	
R2	0.048	
Adjusted R2	0.040	
2020-cohort		
Access to stumping saw (yes=1)	0.081***	
	(0.016)	
Access to wheelbarrow (yes=1)		-0.001
		(0.047)
Control variables	Yes	Yes
Constant	-0.573***	0.481**
	(0.174)	(0.206)
Comparison mean	0.204	0.578
Obs.	1,862	1,864
R2	0.053	0.072
Adjusted R2	0.045	0.063

Source: Sidama coffee program baseline and endline surveys collected in April 2021 (2019-cohort) and June 2023 (2020-cohort).
Note: Control variables include household demographics (household head age and education, household size); assets (land, livestock, durables); coffee farm characteristics (coffee area, number and age of coffee trees); access to services measured through distance to mill, road, and woreda center; and membership in a cooperative.

5.3. Farm support, farm ambassador, and best practice adoption

At the end of the regular CFC trainings, the program introduced two exit strategies to provide continued support and keep momentum on adoption of best practices. The first strategy involved a “farm support” visit by FTs to households that participated in the CFC program and requested additional support at the end of the final training session. While these visits were specifically designed to support households to stump their coffee trees and to set up and maintain compost heaps, FTs also provided support on other activities, such as weeding, erosion control, and updating of record bookkeeping. The farm support intervention was implemented for about four months (February–May 2021), right after the last training, during which FTs were able to conduct more than 10,000 visits. Due to the delayed start of the farm support intervention, most visits were conducted in the second half of March after the stumping season, so we do not anticipate an impact on stumping adoption and intensity.

The second exit strategy used Focal farmers as “farm ambassadors” and combined regular capacity-building meetings with Focal farmers and targeted group farm visits to encourage adoption of best practices promoted by the program. The capacity-building meetings were designed to support farm ambassadors in encouraging adoption of best practices in their communities (FFGs). The group farm visits, aimed at facilitating experiential learning, involved the farm ambassador visiting the farms of group members for hands-on support as well as inviting fellow farmers to visit the farm where the ambassador implemented the best practices. The farm ambassador model ran for 12 months following the farm support intervention and its implementation was largely conditioned by ambassadors’ discretionary decision to set (group) farm visits.

We assess the impact of these exit strategies on best practice adoption among farmers of the 2019-cohort, using a cluster RCT covering the 34 kebeles in Dale and Aleta Chuko woredas where the regular CFC program was implemented. Accordingly, within each woreda, kebeles were randomly allocated to one of the following study arms:

> Treatment group 1 (denoted “farm support”): Trained farmers received farm support from FTs if they requested it during the four months right after the final CFC training
>
> Treatment group 2 (denoted “farm support + farm ambassador”): Trained farmers received the farm ambassador intervention for 12 additional months on top of the farm support visit by FTs
>
> Control group (denoted “control”): No additional support was provided after completion of the CFC training

With this design, we are able to test the impact of the farm support intervention on adoption of best practices in the short to medium term as well as the additional impact of the farm ambassador intervention. (One limitation with this cluster RCT is that the numbers of clusters per study arm are small (11 or 12 clusters or kebeles per study arm) and the study may not be powered to detect small but meaningful impacts.)

Sample households for the assessment were selected from the list of trained households in the final attendance database maintained by TNS, following a two-stage clustered random sampling method, with stratification at the kebele level.[15] At the first stage, seven to eight FFGs were randomly selected from each kebele. At the second stage, four sample households were randomly selected from each FFG. Through this process, a total of 1,040 trained households were selected from 260 FFGs in 34 kebeles. Two rounds of data collection were conducted by Laterite in collaboration with TNS. The first round was conducted in July 2021 after completion of the farm support intervention and data were collected from 1,040 households (of which 9.5 percent were secondary or replacement samples). The second round

[15] Households are considered trained when at least one member of the household has attended 50 percent or more of the CFC modules. In the 2019-cohort, more than 22,000 farm households were trained by the program.

was conducted at the end of the farm ambassador intervention in July 2022 and about 98 percent (1,017) of the sample households were revisited/interviewed.

The random assignment of kebeles into the study arms and the random selection of sample households generated comparable treatment and control groups at household level (Appendix Table A.6 presents the balance tests). The compliance rates were also high, given that farm households are supposed to determine whether they wish to receive follow-up support (in the case of the farm support intervention) and farm ambassadors are not strictly required to follow any procedure or conduct a set of activities (in the case of the farm ambassador intervention). About 70 percent of households reported receiving a farm support visit by an FT or a visit by a farm ambassador. However, only about 46 percent of the sample households in Treatment group 2 received both farm support and farm ambassador visits.

We estimated the impact of the exit strategies following an ITT approach, which captures the effect of being randomly assigned to a kebele where the exit strategies were introduced, regardless of whether the household actually received the interventions. In other words, our estimation includes all sample households whether or not they received the farm support and/or ambassador visits, since both interventions are open to all trained households and FFGs. ITT estimates are relevant from a policy perspective since they measure the average changes in adoption of best practices across all individuals targeted by the interventions. Given that full compliance is nearly impossible in a real-world scenario, ITT estimates are a good proxy for impacts that can be expected beyond the experimental setting. Moreover, to estimate the impact on the treated households, we would have to assume an absence of spillover, an overly restrictive assumption given the likely sharing of information between farmers within a kebele.

To assess the short-term effect of the farm support visit, we estimated the following specification:

$$y_i = \alpha + \beta T_k + \theta X_i + \varepsilon_i \qquad (3)$$

where y_i is the outcome of interest (that is, adoption of best practices) for sample household i; the variable T_k indicates the treatment status of kebele k, which in this specification combines both treatment arms (that is, farm support and farm support + farm ambassador) into a single treatment, since only the farm support was provided in the first four months of the exit interventions period; X_{it} denotes a vector of household-specific/level control variables; and ε_{it} is a random component. We clustered the standard errors at the kebele level to account for treatment assignment at this level.

We also estimated the ITT effect for each of the two treatment arms, measuring the differential impact of farm support when it is provided as a stand-alone exit strategy and when it includes or is followed up with a farm ambassador intervention. The differential effect is estimated using the following specification:

$$y_i = \alpha + \beta^1 T_k^1 + \beta^2 T_k^2 + \theta X_i + \varepsilon_i \qquad (4)$$

where T_k^1 is the treatment for farm support and T_k^2 is the treatment for farm support + farm ambassador. We also test the equality of coefficients between farm support and farm support + farm ambassador (that is, $\beta^1 = \beta^2$) to assess the additional impact of providing the farm ambassador intervention.

Table 5.4. presents the results on the short-term impacts of the farm support intervention. We observe a positive impact on erosion control and record keeping, even though the effect on the former is largely driven by a substantial decrease in the adoption of erosion control practices by households in the control group (rather than an increase in their adoption by households in the treatment group). In other words, farm support helps maintain the effects of the CFC training on erosion control. The impact on record keeping is also corroborated by the qualitative narratives, which indicate that FTs supported farmer households to update their records during the farm support visit. No statistically significant effect is observed on stumping and coffee nutrition, the main outcomes the farm support intervention intended to improve. In fact, a declining trend on adoption of stumping has been observed since 2019 and we understand from the qualitative narratives that most farmers want to see its impact on yield firsthand before stumping at scale on a yearly basis.

Table 5.4. Estimates of the impacts of farm support on best practices adoption

	Coffee nutrition	Weeding	Shade	Erosion control	IPDM	Record keeping	Stumping
Farm support	-0.006	-0.055	-0.002	0.102**	0.009	0.069***	0.038
	(0.031)	(0.039)	(0.037)	(0.038)	(0.011)	(0.022)	(0.031)
log (age of household head in years)	-0.038	-0.048	-0.113**	-0.056	0.001	0.004	-0.028
	(0.047)	(0.039)	(0.050)	(0.059)	(0.017)	(0.037)	(0.049)
log (household size)	0.037	0.062*	0.094**	0.033	0.038*	-0.021	0.070
	(0.039)	(0.032)	(0.042)	(0.052)	(0.020)	(0.019)	(0.050)
Head has attended elementary education	0.018	-0.002	0.003	-0.061**	-0.023	0.020	0.016
	(0.031)	(0.032)	(0.039)	(0.029)	(0.018)	(0.028)	(0.034)
Head has attended secondary education or higher	0.036	-0.028	0.009	-0.039	-0.031*	0.035	0.072*
	(0.042)	(0.037)	(0.059)	(0.041)	(0.017)	(0.029)	(0.040)
Household is member of cooperative	0.035	0.087**	0.039	0.004	-0.019	0.007	0.024
	(0.027)	(0.037)	(0.038)	(0.029)	(0.012)	(0.018)	(0.031)
Livestock owned (in TLU)	0.010	0.009	0.004	0.001	-0.002	-0.015**	0.013
	(0.008)	(0.010)	(0.011)	(0.007)	(0.003)	(0.006)	(0.010)
Durable asset owned (in PCA)	0.001	0.017	-0.005	0.013	-0.001	-0.001	0.023**
	(0.007)	(0.010)	(0.009)	(0.013)	(0.003)	(0.005)	(0.010)
log (area of coffee farm in hectares)	-0.011	-0.289***	0.174*	0.137	0.027	0.110**	0.165**
	(0.053)	(0.078)	(0.090)	(0.106)	(0.028)	(0.053)	(0.066)
Dale woreda	0.131***	0.176***	0.210***	0.088*	0.050***	-0.013	0.005
	(0.031)	(0.053)	(0.050)	(0.046)	(0.014)	(0.023)	(0.043)
Constant	0.813***	0.255	0.386*	0.339	-0.042	0.041	0.117
	(0.194)	(0.185)	(0.194)	(0.244)	(0.045)	(0.147)	(0.202)
Control mean	0.65	0.16	0.37	0.12	0.19	0.02	0.25
Number of observations	1,038	1,038	1,038	1,038	1,038	1,038	1,038
R2	0.042	0.091	0.073	0.036	0.028	0.031	0.045
Adjusted R2	0.033	0.082	0.064	0.027	0.018	0.021	0.036

Source: Authors' calculation based on August 2021 and July 2022 farm support and ambassador assessment surveys.
Note: ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively.

Comparable results are observed from the second-round survey conducted 12 months after completion of the farm support intervention (Table 5.5.). The farm support intervention has no statistically significant effect on best practices adoption in the medium term, except on record keeping. As indicated above, the effect on record keeping is also corroborated by the qualitative discussion/case studies: FTs help households in updating their records during farm support visits. Similarly, farm ambassadors have no significant impact on most of the best practices promoted by the program. The only positive impact observed is on adoption of erosion control, again mainly driven by a substantial decrease in adoption of these practices by households in the control group. The negative impact on IPDM observed across the two treatment arms is mainly explained by a significant improvement in IPDM knowledge (adoption) among households in the control group (not due to a decline in IPDM knowledge/adoption among the treatment groups). Only in erosion control and record keeping do we observe statistically different effects in magnitude across the two treatment arms (see the F-statistics in the last row of Table 5.5). This implies that the farm ambassador treatment did not have an additional/incremental effect on adoption of best practices. (We obtain comparable results when we combine the two treatment arms; see Appendix Table A.7.)

Table 5.5. Estimates of the impacts of farm support and farm ambassador on best practices adoption

	Coffee nutrition	Weeding	Shade	Erosion control	IPDM	Record keeping	Stumping
Farm support (FS)	0.025	0.043	-0.001	0.055	-0.055*	0.061***	0.029
	(0.065)	(0.086)	(0.051)	(0.044)	(0.029)	(0.021)	(0.043)
FS + farm ambassador	0.022	0.099	-0.073	0.152***	-0.080***	0.019	0.009
	(0.040)	(0.087)	(0.055)	(0.054)	(0.029)	(0.012)	(0.041)
log (age of household head in years)	-0.150**	0.013	-0.029	-0.052	0.042	-0.034*	-0.042
	(0.056)	(0.060)	(0.064)	(0.048)	(0.048)	(0.020)	(0.061)
log (household size)	0.043	0.012	-0.062	0.034	0.102**	0.035*	0.147***
	(0.051)	(0.043)	(0.062)	(0.035)	(0.039)	(0.020)	(0.037)
Head has attended elementary education	0.095**	-0.082**	-0.014	0.015	0.042	0.012	-0.011
	(0.038)	(0.036)	(0.044)	(0.032)	(0.042)	(0.016)	(0.030)
Head has attended secondary education or higher	0.059	-0.035	-0.033	0.051	0.069	0.001	0.082**
	(0.041)	(0.038)	(0.054)	(0.040)	(0.044)	(0.018)	(0.040)
Household is member of coop	-0.017	0.110**	-0.063**	0.048	-0.061**	0.018	0.066**
	(0.043)	(0.041)	(0.030)	(0.035)	(0.030)	(0.011)	(0.030)
Livestock owned (in TLU)	-0.005	0.004	0.011	0.003	0.004	-0.007**	0.011
	(0.014)	(0.012)	(0.011)	(0.008)	(0.009)	(0.003)	(0.012)
Durable asset owned (in PCA)	0.016	0.010	0.015	0.009	0.001	-0.000	0.004
	(0.010)	(0.011)	(0.009)	(0.013)	(0.008)	(0.003)	(0.010)
log (area of coffee farm in hectares)	0.142	-0.277***	0.255**	-0.042	-0.049	0.031	0.202***
	(0.090)	(0.081)	(0.098)	(0.074)	(0.066)	(0.030)	(0.073)
Dale woreda	-0.152***	-0.015	-0.053	0.011	0.135***	0.036**	0.036
	(0.049)	(0.068)	(0.041)	(0.041)	(0.025)	(0.017)	(0.037)
Constant	1.117***	0.162	0.581**	0.209	-0.210	0.052	-0.018
	(0.221)	(0.254)	(0.272)	(0.192)	(0.169)	(0.094)	(0.233)
Control mean	0.65	0.157	0.373	0.122	0.19	0.017	0.248
Number of observations	1,012	1,012	1,012	1,012	1,012	1,012	1,012
R2	0.048	0.041	0.026	0.035	0.061	0.036	0.062
Adjusted R2	0.037	0.031	0.015	0.024	0.051	0.026	0.052
F test	*0.000*	*0.470*	*1.900*	*3.160*	*0.690*	*4.070*	*0.170*
Prob F	*0.948*	*0.499*	*0.177*	*0.085*	*0.412*	*0.052*	*0.682*

Note: ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively.
Source: Authors' calculation based on August 2021 and July 2022 farm support and ambassador assessment surveys.

5.4. Incentives and stumping

Besides the coffee rejuvenation training (delivered as part of the CFC), the 2020-cohort program offered packages of agricultural tools as an incentive to encourage the adoption and intensity of stumping right after the final rejuvenation training. The incentive packages consisted of a combination of tools (that is, stumping saws, secateurs, and wheelbarrows). Farm households' eligibility to receive the tools depended on their stumping a certain number of coffee trees (that is, meeting a threshold). The program kebeles were randomly assigned to four stumping incentive eligibility thresholds and a control group to understand the impacts of incentive offerings as well as the cost-effective threshold (number of coffee trees) that households are willing to meet in exchange for a given incentive package. Within the treatment group, the stumping incentives were further structured into two thresholds: a lower bound in which households received a saw and secateurs for stumping at least 50 coffee trees, and a higher bound in which households received a wheelbarrow (in addition to a saw and secateurs) for stumping either 100 (Group 1 kebeles), 150 (Group 2 kebeles), 200 (Group 3 kebeles), or 250 (Group 4 kebeles) coffee trees.

Since the stumping incentive was implemented as an add-on at the end of the 2020-cohort training and evaluated separately, we estimate the additional impact of the stumping incentive on adoption and intensity of stumping using the endline outcome measures of the stumping survey collected after the introduction of the incentive packages. Thus, we are mainly interested in the additional impact of offering incentives and its interaction effect with the rejuvenation training (see the standalone evaluation of the stumping incentive by Laterite for the main effects irrespective of rejuvenation training participation).

We estimate the differences in adoption and intensity of stumping due to rejuvenation training and stumping incentive offered using a full model with interaction between the two treatments. Specifically, we use the following specification to estimate the adoption and intensity of stumping of farm household *i* observed at the endline stumping survey:

$$\tau_{i,t=1} = \delta D_i + \beta_1 G_i^1 + \beta_2 G_i^2 + \beta_3 G_i^3 + \beta_4 G_i^4 + \beta_5 (D_i * G_i^1) + \beta_6 (D_i * G_i^2) + \beta_7 (D_i * G_i^3) + \beta_8 (D_i * G_i^4) + \gamma \tau_{i,t=0} + X'_{i,t=0} \vartheta + \varepsilon_i, \quad (5)$$

where $\tau_{i,t=1}$ is the household stumping adoption rate and intensity at endline and $\tau_{i,t=0}$ is the same at baseline. D_i, the main treatment (that is, rejuvenation training) indicator variable, has a value of one if the household participated in a rejuvenation training between 2020 and 2022, and zero otherwise. The average effect of the rejuvenation training on adoption and intensity of stumping relative to untrained participants is quantified by δ. Variables G_i^1, G_i^2, G_i^3, and G_i^4 are time-invariant incentive treatment indicator variables, with a value of one if the household is randomly assigned to Group 1, Group 2, Group 3, and Group 4, respectively, and zero otherwise. The average effects of the incentive treatment groups (thresholds) on adoption and intensity of stumping relative to the control group are quantified by β_1 to β_4, while β_5 to β_8 capture the interaction effect between the rejuvenation training and the different incentive treatment groups. Vector $X'_{i,t=0}$ includes household- and farm-level controls measured at baseline and woreda-level fixed effects. To assess whether our estimates are sensitive to the inclusion of household- and farm-level controls, we estimate our results with and without the vector $X'_{i,t=0}$.

Table 5.6 shows the estimates of the impact of the rejuvenation training and stumping incentives on farm households' adoption and intensity of stumping. Three results are noteworthy. First, there is a meaningful and statistically significant effect of the rejuvenation training on the adoption and intensity of stumping even after accounting for the incentive provisions. While accounting for the incentive package slightly reduces the size of the estimates (compare Figures 5.7–5.9), the effect sizes (magnitudes) are largely comparable.

Table 5.6. Estimates of the impacts of coffee rejuvenation training and stumping incentives on the adoption and intensity of coffee stumping

	Stumping adoption		Number of stumped coffee trees		Share of stumped coffee trees	
	(1)	(2)	(3)	(4)	(5)	(6)
Rejuvenation training	0.281***	0.233***	10.791***	3.531	2.753*	2.920*
(2020–2022, yes=1)	(0.078)	(0.084)	(2.687)	(3.870)	(1.506)	(1.735)
Group 1	-0.060	-0.066	1.886	1.401	-1.297	-1.226
	(0.091)	(0.095)	(4.275)	(5.402)	(1.613)	(1.897)
Group 2	-0.080	-0.075	-0.751	0.176	-1.759	-2.525
	(0.083)	(0.090)	(1.212)	(4.126)	(1.295)	(1.759)
Group 3	0.062	0.051	3.783*	2.279	0.788	1.027
	(0.092)	(0.098)	(2.243)	(4.195)	(1.708)	(2.048)
Group 4	-0.015	-0.040	2.457	1.468	0.499	0.022
	(0.079)	(0.086)	(1.905)	(3.842)	(1.630)	(1.775)
Rejuvenation training	0.090	0.084	10.091	9.548	3.723*	3.476
*Group 1	(0.108)	(0.110)	(7.258)	(7.260)	(2.144)	(2.334)
Rejuvenation training	0.134	0.148	7.173*	6.059	5.488***	6.330***
*Group 2	(0.100)	(0.102)	(3.971)	(5.030)	(1.903)	(2.093)
Rejuvenation training	-0.093	-0.079	-3.680	-2.575	-0.690	-0.824
*Group 3	(0.109)	(0.113)	(4.325)	(5.483)	(2.074)	(2.355)
Rejuvenation training	-0.047	-0.030	-1.039	-0.359	1.692	2.222
*Group 4	(0.100)	(0.105)	(4.827)	(5.596)	(2.283)	(2.458)
Baseline value	Yes	Yes	Yes	Yes	Yes	Yes
Control variables	No	Yes	No	Yes	No	Yes
Constant	0.152**	-0.729***	1.286	-60.394***	1.941	-8.087
	(0.067)	(0.273)	(1.121)	(21.673)	(1.289)	(7.131)
Number of observations	940	940	940	940	940	940
R2	0.080	0.124	0.076	0.192	0.051	0.077
Adjusted R2	0.070	0.099	0.066	0.169	0.041	0.050

Note: ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively.
Source: Authors' calculation based on 2020 and 2022 baseline and stumping surveys.

Second, the incentive packages did not yield a statistically significant impact on adoption of stumping once we account for farm households' (self-reported) participation in rejuvenation training (Table 5.6). In other words, no statistically distinguishable difference exists in the adoption of stumping between topic-trained households in the incentive groups and in the control group. This is plausible given that training is indispensable for introducing new practices to farmers and encouraging them to try the practices.

Third, the intensity of stumping (that is, number and share of coffee trees stumped) by topic-trained farm households in Group 1 and Group 2 is significantly higher than that of trained households in the (incentive) control group, indicating synergies between the rejuvenation training and the incentive provision for farm households in these groups (Table 5.6). No such results are found on adoption (despite the positive and relatively larger coefficients for farm households in Group 3). This indicates that conditioning incentive provision based on intensity of stumping is effective up to a certain threshold (that is, 150 coffee trees, the higher threshold for Group 2) for trained households. When the threshold is set higher than this level, it appears to be less effective, if not discouraging (see Appendix Table A.8 for additional results for any incentive groups and the combination of the first two and last two incentive study groups).

5.5. Stumping and coffee yield

Improving the income of coffee farmers by increasing farm productivity is the final outcome of the program. A pilot yield measurement survey was conducted by Laterite (in collaboration with TNS) to assess the impact of stumping on coffee yield three years after completion of the CFC for the 2019-cohort. The yield assessment was conducted on coffee farms that were selected through a two-step process: 1,132 eligible farms (from a total of 34,584 farms in the 2019-cohort) where trained households had stumped at least 40 trees in the 2019 stumping season were first selected (shortlisted) based on stumping data extracted from TNS's attendance database. Next, 338 farms were randomly selected from the eligible farms for the screening survey to determine a sample of farms with two comparable 10m x 10m plots with stumped and unstumped coffee trees—with the unstumped plot ideally located adjacent to a stumped plot on the same coffee field. Based on the screening survey (which includes a detailed plot assessment, tree counts, and images), 111 farms meeting the prespecified criteria were selected for the yield assessment survey.

Data on harvest and other key variables (that is, number of coffee trees in the 10m x 10m plots, age and height of coffee trees, and application of complementary best practices) were collected toward the end of 2022. The coffee harvest data collection involved measuring the full harvest from the stumped and unstumped plots throughout the duration of the harvest (October 2022–January 2023) with the support of FTs. During each round of harvest, FTs were present to ensure that the harvest from the stumped and unstumped plots were placed into clearly marked sacks and weighed separately. However, minor measurement issues still arose due to scale placement and inconsistencies in tree counts; these were verified and corrected.

Using these data, we estimate the impact of stumping on coffee yield accounting for other complementary best practices, such as composting, weeding, and shade management. Specifically, we use the following specification to estimate the (conditional) impact of stumping on coffee tree yield:

$$lnY_{hp} = \alpha_h + \varphi Rejuvenated_{hp} + \theta X_{hp} + \varepsilon_{hp} \quad (6)$$

where lnY_{hp} is the log yield per tree associated with household h and plot p; $Rejuvenated_{hp}$ is a binary indicator assuming a value of one for stumped coffee plots and zero for unstumped ones; θX_{hp} captures a set of observable plot-level characteristics; α_h stands for household fixed effects that capture all time-invariant differences across households; and ε_{hp} contains other (un)observable factors that contribute to explaining coffee tree yield.

Table 5.7 presents the unconditional and conditional impacts of stumping on coffee yield. Both sets of estimates point to a clear and meaningful effect of rejuvenation on coffee tree productivity. Looking at the unconditional estimate (column 1), the results show a 36 percent higher average coffee tree yield on stumped versus unstumped plots. The yield impact of stumping on tree yield increases to 38 percent when we account for the number of coffee trees on the 10m x 10m stumped and unstumped plots (column 2).[16] While the impact of rejuvenation on yield is relatively lower when we account for complementary best practices (for example, weeding, shade management, composting) and tree characteristics (for example, age and height of coffee trees), the magnitude remains substantial. Coffee trees on stumped plots yield 21–23 percent more beans than trees on unstumped coffee plots even after accounting for complementary best practices, tree characteristics, and location (columns 3 and 4).

Table 5.7. Estimates of the impacts of coffee rejuvenation/stumping on coffee yield

	Dependent variable: log(yield, in cherries)			
	(1)	(2)	(3)	(4)
Rejuvenated plot (yes=1)	0.357***	0.379***	0.231**	0.208**
	(0.034)	(0.032)	(0.097)	(0.083)
Number of coffee trees		-0.010**	-0.011***	-0.018***
		(0.004)	(0.004)	(0.004)
Age of coffee trees			-0.002	0.001
			(0.010)	(0.007)
Height of coffee trees			-0.096	-0.130**
			(0.067)	(0.054)
Mulch seen on the plot (yes=1)			0.152	0.164
			(0.115)	(0.099)
Sufficient weeding (yes=1)			0.086	-0.014
			(0.079)	(0.074)
Sufficient shade (yes=1)			0.272***	0.202***
			(0.080)	(0.076)
Application of compost (yes=1)			0.204**	0.172**
			(0.080)	(0.075)
Dale woreda				0.406***
				(0.073)
Constant	0.569***	0.808***	1.027***	1.166***
	(0.047)	(0.120)	(0.353)	(0.285)
Number of observations	222	222	222	222
R2	0.121	0.147	0.271	0.393
Adjusted R2	0.117	0.140	0.243	0.367

Source: Authors' calculation based on October 2022–January 2023 coffee yield measurement survey.
Note: ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively.

While these results are for the average yield of coffee trees in stumped and unstumped coffee plots, it is worth noting that the data show substantial variation in the yield per tree within the same plot,

[16] The average number of coffee trees on the 10m x 10m stumped and unstumped coffee plots was 26 and 24, respectively.

presumably due to different abiotic and biotic factors that affect coffee yield. The box plot in the Appendix clearly shows that most trees on stumped plots are more productive than trees on unstumped plots. Specifically, while yield per tree ranges from 1.3 kilograms (kg) to 4.9 kg cherries on stumped plots, with 50 percent of trees producing more than 2.5 kg cherries, the corresponding figures for unstumped plots are 0.9 kg to 4.0 kg cherries, with only 25 percent of trees producing more than 2.5 kg cherries (Appendix Figure A.4). The results based on total coffee harvest on stumped versus unstumped coffee plots show comparable results (Appendix Table A.9).

Besides the yield impact of stumping, we attempted to qualitatively assess the changes in yield for the entire sample by directly asking farmers about their perception/observation regarding yield improvements after the program. Such perceptions vary considerably when farmers are asked to compare the harvest after the program with the harvest before the program (no timeframe specified) versus the harvest before two years ago. A sizable share (53–78 percent) reported an increase in volume of harvest when asked to compare the current harvest with that with before the program (presumably due to social desirability bias) than when asked to compare it with the harvest two years ago: only 3–10 percent of households reported an increase in volume of harvest when asked to compare it with the volume harvested two years ago.

5.6. Social Return on Investment (SROI)

In this section, we present the summary of the Social Return on Investment (SROI) valuation estimated by HWG based on the program impact on adoption of best practices reported in Section 5.1.[17] The SROI aims to assess whether the program benefits outweigh its costs and if not, to simulate the level of impact or conditions needed for them to do so. The SROI is measured as follows:

$$SROI = \frac{PV_{benefits}}{PV_{costs}}$$

The present value of program benefits ($PV_{benefits}$) is calculated using the following formula:

$$PV_{benefits} = \sum_{n=0}^{N} \frac{B_n}{(1+r)^n}$$

where N is the number of years of projected program benefits considered in the calculation (here 10); B represents the program benefits, consisting of the additional income gain for trained households in each year; and r is the discount rate (here 10 percent).

The present value of program benefits includes all discounted increases in coffee income attributable to the program over a period of 10 years from program start; that is, due to adoption of stumping and other complementary best practices. (Indirect benefits of the program at the individual household or community level are not included and may result in underestimation of program benefits.) The present value of program costs (PV_{costs}) mainly includes the cost of program implementation. An SROI value greater than one indicates that the program generated more benefits than its costs; a value less than

[17] More information on the SROI method, underlying data, and assumptions can be found in a dedicated SROI report available by HWG upon request.

one indicates the converse; and a value of exactly one indicates the breakeven point where program benefits are equal to its costs. As indicated above, both the program's benefits and costs are discounted using a discount factor of 10 percent (a commonly used rate by the World Bank for return on investment valuation) and the estimation allows for a cash flow of 10 years.

The SROI estimations for the 2019- and 2020-cohorts consider the following three scenarios observed in practice: (i) target households continue to manage their coffee farms as at baseline and produce low but stable yields (no adoption, or business as usual); (ii) households adopt four or more best practices (other than stumping) to modestly increase yields without incurring temporary production losses due to stumping (adoption of best practices, no stumping); and (iii) households stump some of their coffee trees along with complementary best practices to maximize yield gains (adoption of best practices, including stumping). The program benefits are estimated for all three scenarios based on the following impact that is "attributable" to the program and assumptions in cases where the program evaluation does not provide sufficient evidence to know the actual (yield) benefits of adopting a given practice or set of practices:

- The program targeted 33,441 coffee-producing households in the 2019-cohort and 26,414 households in the 2020-cohort. Of these, 22,277 households in the 2019-cohort and 20,125 households in the 2020-cohort were trained, according to TNS's training attendance database.[18]
- The program increased adoption of stumping by 10.8 and 17.0 more coffee trees for the average household in the 2019- and 2020-cohorts, respectively (based on the endline stumping survey, which counted stumped coffee trees by sample households on best practice plots and collected self-reported stumped coffee trees on other coffee plots). Based on TNS's yield model, the yield of stumped coffee trees is estimated to be threefold its baseline value after three years of rejuvenation. (This is much higher than the 21–38 percent yield gain observed in the pilot yield assessment and may result in an overestimation of program benefits.)
- About 12 percent of households were counted as adopters of four or more best practices (out of seven) due to the program in both cohorts. The yield benefit of adopting at least three basic good agricultural practices is estimated at 10 percent.
- The yield benefits perpetuate until 2028 for the 2019-cohort and until 2029 for the 2020-cohort (eight years from the first year of production after a coffee tree is stumped or rejuvenated).

Considering these elements and assumptions (for example, assuming the five-year average coffee price from 2019–2023 is maintained until 2029), the discounted program benefits are estimated at 0.87 million Euro (in 2021 prices) for the 2019-cohort and 1.43 million Euro (in 2021 prices) for the 2020-cohort (Figure 5.10). The program cost is based on TNS's official budget expenditures for project

[18] Here we use the implementer's definition of a trained household. A household is considered "trained" if at least one member attended at least 50 percent of the training topics. Following this definition, we consider a household trained if it reports attendance in at least four of the seven key training topics considered in this evaluation.

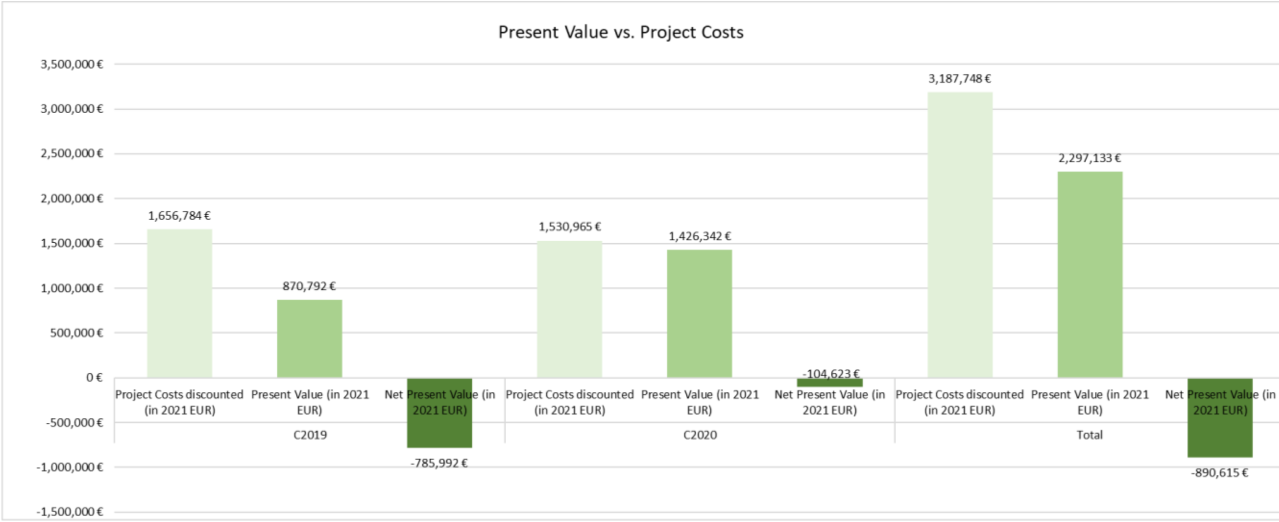
implementation, and the discounted program costs are estimated at 1.657 million Euro (in 2021 prices) for the 2019-cohort and 1.531 million Euro (in 2021 prices) for the 2020-cohort.

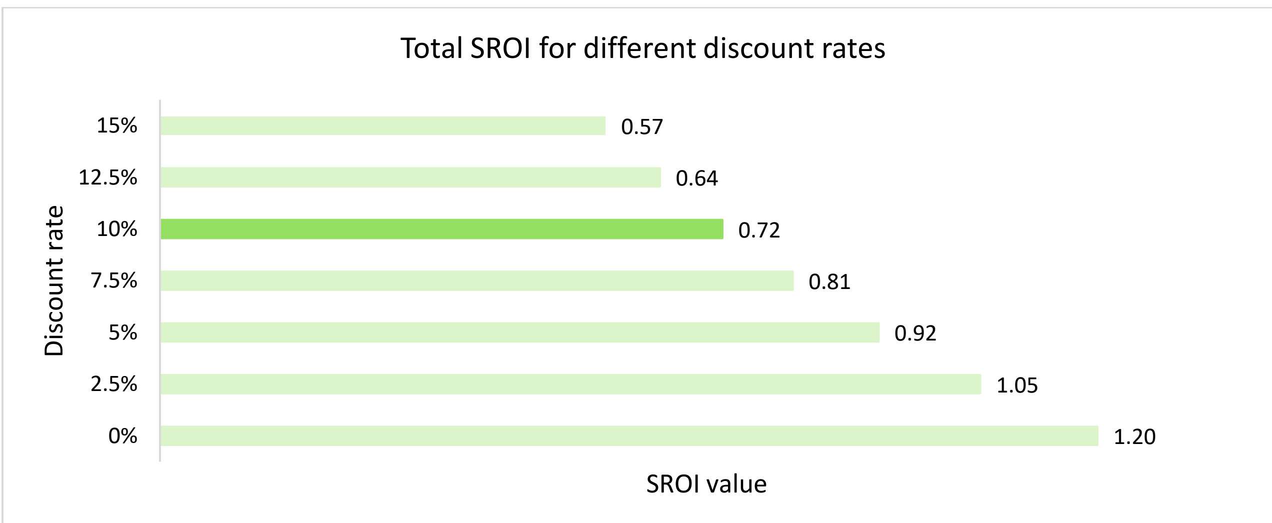
The SROI based on these estimates indicates a critical picture. The results for the 2019-cohort show that the program did not break even at the 10 percent discount rate. Specifically, program costs are 47 percent higher than program benefits at the 10 percent discount rate. In other words, program benefits amount to only 53 percent of program costs. The results for the 2020-cohort indicate that here the program is closer to break even, with program benefits making up 93 percent of program costs at the 10 percent discount rate. This could be due to the additional effect of incentives on the number of coffee trees stumped, a key parameter in the SROI calculation. The overall SROI for the Sidama coffee program (for both cohorts) is 0.72 at the 10 percent discount rate, implying that program benefits amount to only 72 percent of costs. Figure 5.11 shows the SROI at different discount rates, illustrating that program benefits do match costs using a discount rate around 3%. At a zero percent discount rate (a discount rate rarely used for projects with long-term benefits for the climate) the program generates positive returns. Low uptake and intensity of stumping and the small change in overall farm management seemingly limit the program's potential to accrue benefits that can meaningfully exceed its costs at the commonly used 10 percent discount rate. The low coffee prices at baseline (which deflate program effects) and small coffee areas per farm household seem to adversely affect the program's potential to generate meaningful returns.

A sensitivity analysis shows how much the above-mentioned conditions/impact and assumptions need to change for the program's benefits to match (or exceed) its costs. For example, for the 2019-cohort, adoption of basic best practices has to increase to 38 percent (from the 12 percent considered in the model based on the endline results). Alternatively, the yield benefits from adopting basic best practices (other than stumping) should increase to 31 percent (from the 10 percent yield increase assumed in the current estimation of program benefits). Given that little empirical evidence exists on the yield effects of best practice adoption for Arabica coffee, a 31 percent yield increase seems optimistic but may be possible. Another route to break even is increasing the number of coffee trees stumped on the best practice plot by an average trained household to 22 and 17 trees for the 2019- and 2020-cohort, respectively (from 7.5 and 14 trees, as reported by the endline stumping survey).

The SROI results should be interpreted with caution for a couple of reasons. One, an evidence gap remains in the general yield effects of best practices adoption, and more research is needed to precisely estimate yield benefits. Similarly, the long-term yield effects of stumping (the key best practice for increasing productivity) are not fully understood and require a carefully designed multiyear study on farmers' coffee fields. Second, the current SROI valuation does not include the indirect (spillover) impacts of the program, which could be substantial. Third, the evaluation data do not allow us to estimate the dynamic effects of training on yield; it is possible that the effect of training increases or diminishes over time. We apply findings from a previous evaluation of TNS's coffee training program in East Africa (Triple Line 2017). The Triple Line evaluation found that 63 percent of the improvement in practices achieved by the end of the training period remained five years later. Assuming practice adoption diminishes linearly implies an annual decay of 7.3 percent of the initial improvement.

Figure 5.11. Discounted program costs and benefits and SROI at different discount rates





Source: SROI estimates by HWG.

These limitations aside, the SROI results clearly suggest that the program should not be replicated under the same conditions, given that the program benefits fall short of covering costs at the commonly used 10 percent discount rate. However, the returns of future programs with a similar concept can be increased through deliberate targeting of regions with relatively large coffee farms (number of coffee trees) per household and higher coffee prices. Moreover, adding additional components such as incentives to compensate for learning costs (for example, production loss due to stumping) can increase the adoption rate and intensity of best practices, thereby substantially increasing program benefits.

6. Conclusions

6.1. Summary of results

This report presents the impacts of a 25-month coffee agronomy training program implemented by TNS—in collaboration with Max und Ingeburg Herz Stiftung/HWG—on adoption of promoted best practices, the effectiveness of exit strategies piloted by the program, the yield impact of stumping, and the program's overall SROI. To understand these impacts, we used multiple quantitative and qualitative data collected by the program's learning partners (IFPRI and Laterite) throughout the program's duration.

We found that that the **farmer mobilization/sign-up process** was perceived as fair and inclusive, with the majority of interested coffee-producing households successfully enrolling in the program. Participation rates on trainings were moderate to high and varied across cohorts: participation rates by training topic range from 36 percent (for record keeping) to 64 percent (for stumping) in the 2019-cohort and from 59 percent (IPDM) to 84 percent (for coffee nutrition) in the 2020-cohort.

The quantitative analysis indicated that TNS's CFC training significantly increased **adoption of best practices**, notably stumping, which increased by 9 and 32 percentage points in the 2019- and 2020-cohorts, respectively. The program also resulted in an increase in the number (share) of stumped coffee trees by 7.5 trees (2.5 percentage points) in the 2019-cohort and by 14.0 trees (5.5 percentage points) in the 2020-cohort. Overall, these results represent a more than twofold increase in the adoption rate and intensity of stumping after the training intervention. Additionally, the program led to a significant increase in the adoption of IPDM and record keeping best practices for both cohorts. For coffee nutrition and soil erosion control best practices, statistically positive improvements were recorded mainly in 2019.

Knowledge improvement from attending the trainings and access to tools such as stumping saws were found to be the main pathways to impact/adoption. For instance, households knowledgeable about coffee nutrition were 36–37 percent more likely to adopt the practice than their counterparts. Similarly, significant correlations were observed between knowledge and adoption for erosion control, record keeping, and stumping in both cohorts. The results also showed that **access to a stumping saw** increased adoption of stumping by about 7–8 percentage points in both cohorts.

Experimental evaluation of two **exit strategy interventions** —farm support and farm ambassador— showed no statistically significant effect on stumping and coffee nutrition, key practices that the interventions mainly intended to improve. The delayed implementation of farm support and the minimal intervention of farm ambassadors are potential reasons for no impact. On the other hand, the provision of packages of agricultural **tools as incentives** to encourage the adoption and intensity of stumping led to an increase in the "intensity" of stumping adoption up to a certain threshold. However, the incentive packages did not result in a statistically significant impact on the adoption (trial) of stumping once we accounted for farm households' participation in rejuvenation training, indicating that training is indispensable for introducing and encouraging the uptake of new farming practices.

A **pilot yield assessment** survey conducted on adjacent plots with stumped and unstumped coffee trees indicated that stumping increases coffee tree yields by about 21 percent after accounting for tree characteristics (for example, age, height), adoption of other complementary best practices (that is, weeding, shade management, composting), and location.

The SROI valuation indicated that the program was not cost-effective, with program benefits amounting to only 72 percent of program costs at the commonly used 10 percent discount rate. The low uptake and intensity of stumping and small changes in overall farm management presumably limited the program's potential to accrue enough benefits to meaningfully exceed its costs.

6.2. Recommendations

Mobilization/sign-up and group formation: While the mobilization and sign-up process was largely viewed as fair and inclusive, farmers were not fully convinced about the value added of having an FFG as additional group structure, since its membership composition is similar to the existing development group. We recommend the use of existing structures by similar programs in the future for two main reasons: (i) farmers are already familiar with the existing group structure, which will reduce the costs associated with group formation; and (ii) these groups will continue to exist beyond the program's lifecycle and will ensure the continuity of discussion on program interventions and their benefits.

Reach, participation, and knowledge gain: The program roll-out was deemed impressive despite challenges like the COVID-19 pandemic. The program reached a large number of farm households and training participation rates were reportedly moderate (2019-cohort) to high (2020-cohort). However, a gap remains in precisely measuring the immediate outputs of participation in trainings. In the current surveys, we attempted to measure knowledge improvements through a set of semi-standardized questions. However, these questions related to farmers' awareness of best practices but less so to their technical knowhow, such as at what height and angle a coffee tree should be stumped. Thus, measuring more precisely technical knowledge gained would be relevant to ascertain the quality of program reach and participation.

Best practices adoption: While the results point to a clear and meaningful impact on adoption (trial) of best practices, impacts on intensity of adoption are either limited (in the case of stumping) or unknown (in the case of other best practices). Given that greater adoption intensity is needed to ensure sufficiently strong yield and income effects, we highly recommend adding complementary interventions that can drive adoption at scale, for instance, by compensating for farmers' cost of learning/adoption (for example, provision of incentives for stumping to compensate for short-term production losses) or facilitating access to tools/inputs for proper implementation of best practices. (While training is indispensable in terms of encouraging farm households to try/adopt new practices, it may not be sufficient to drive adoption at scale at early stages.)

With respect to the evidence gap on measurement of adoption intensity, we recommend including measures that can properly capture the program's impact on the intensive margin for key practices such as composting, weeding, and shade management (besides stumping). There may also be a need to refine adoption measurement/criteria for some of the best practices (for example, shade management).

The adoption results reported above essentially derive from the data collected from the visited (reference) plots of trained farmers. However, evidence exists of adoption of best practices on coffee plots other than the reference plot. Farm households not directly trained by the program could also adopt best practices. Thus, we recommend rigorously measuring the indirect (spillover) effects to capture the full impact of the program. Moreover, it is important to measure the patterns of adoption in the medium to long term (after farm households observe firsthand the yield gains from implementing the promoted best practices) to obtain a complete picture of program impacts.

The yield impact of adopting best practices: The pilot yield assessment provided initial and encouraging evidence about the short-term benefits of stumping on coffee tree yield. However, limited or no empirical evidence exists on the yield impact of other best practices and the long-term yield impact of stumping. A rigorous assessment (evidence) of yield impact on farmers' fields is a necessary condition to recommend/promote adoption of best practices at scale.

Social Return on Investment: The SROI evaluation indicated that the program was not cost-effective. Thus, such a program should not be replicated under the same conditions, given that program benefits amounted to only about 72 percent of program costs. However, as indicated above, the returns of future programs with a similar concept can be increased through deliberate targeting of regions with the right conditions (for example, large coffee farms, areas with higher coffee prices, etc.). More importantly, adding additional components that can increase the adoption rate and intensity of best practices—such as stumping or promoting additional income-generating activities—can substantially increase program benefits. The SROI results from the 2020-cohort corroborate this idea. The SROI for the 2020-cohort is markedly higher (even though the program still does not break-even), presumably due to the additional effect of incentives for the stumping intervention on the number of coffee trees stumped.

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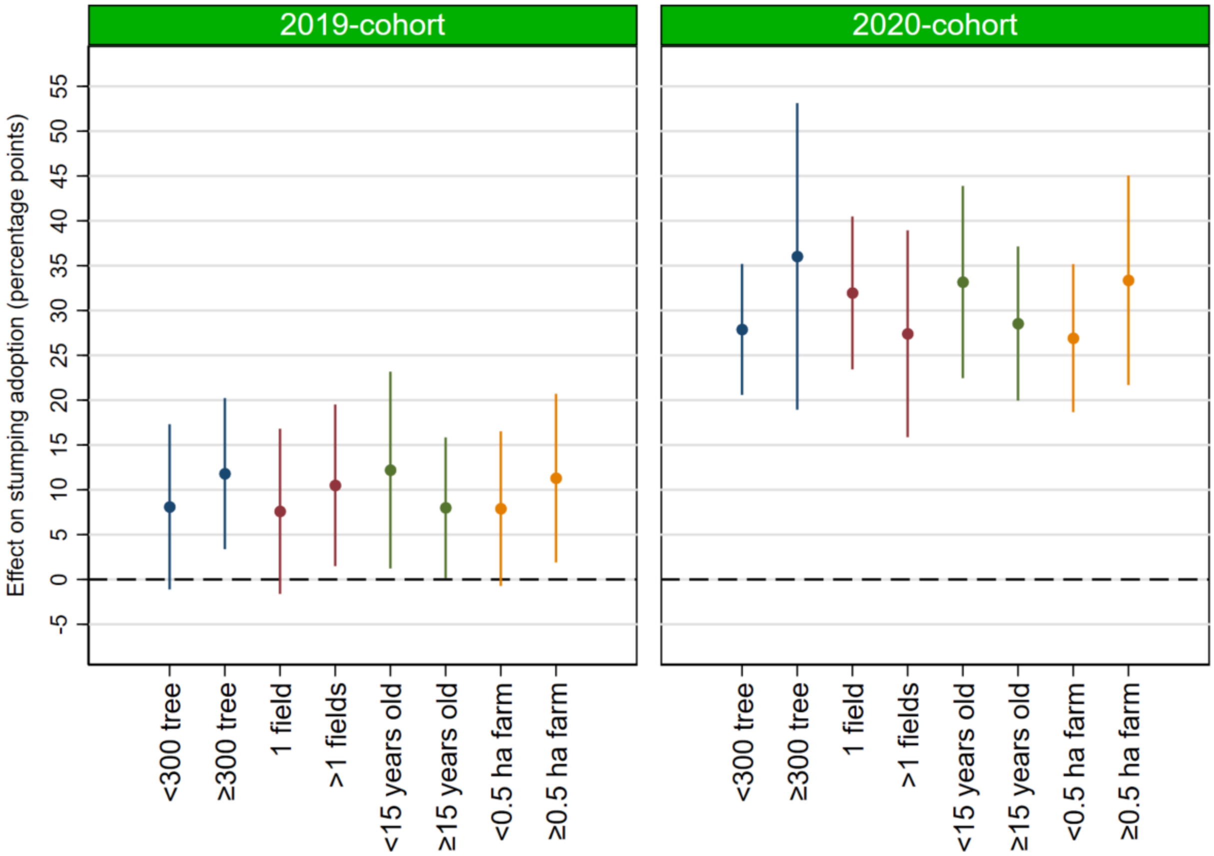
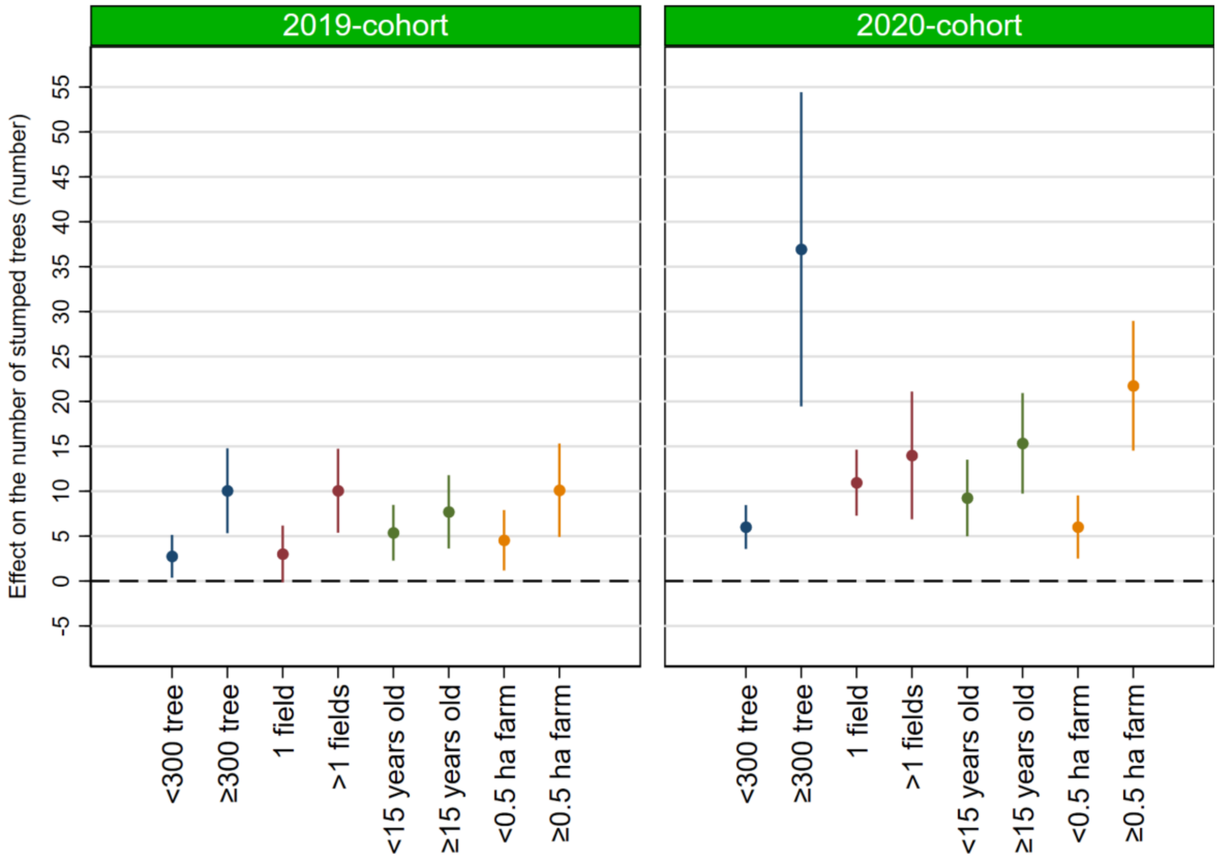
Appendix: Supplementary results figures and tables

Figure A.1. Estimates of treatment effects heterogeneity on adoption of coffee stumping, by cohort



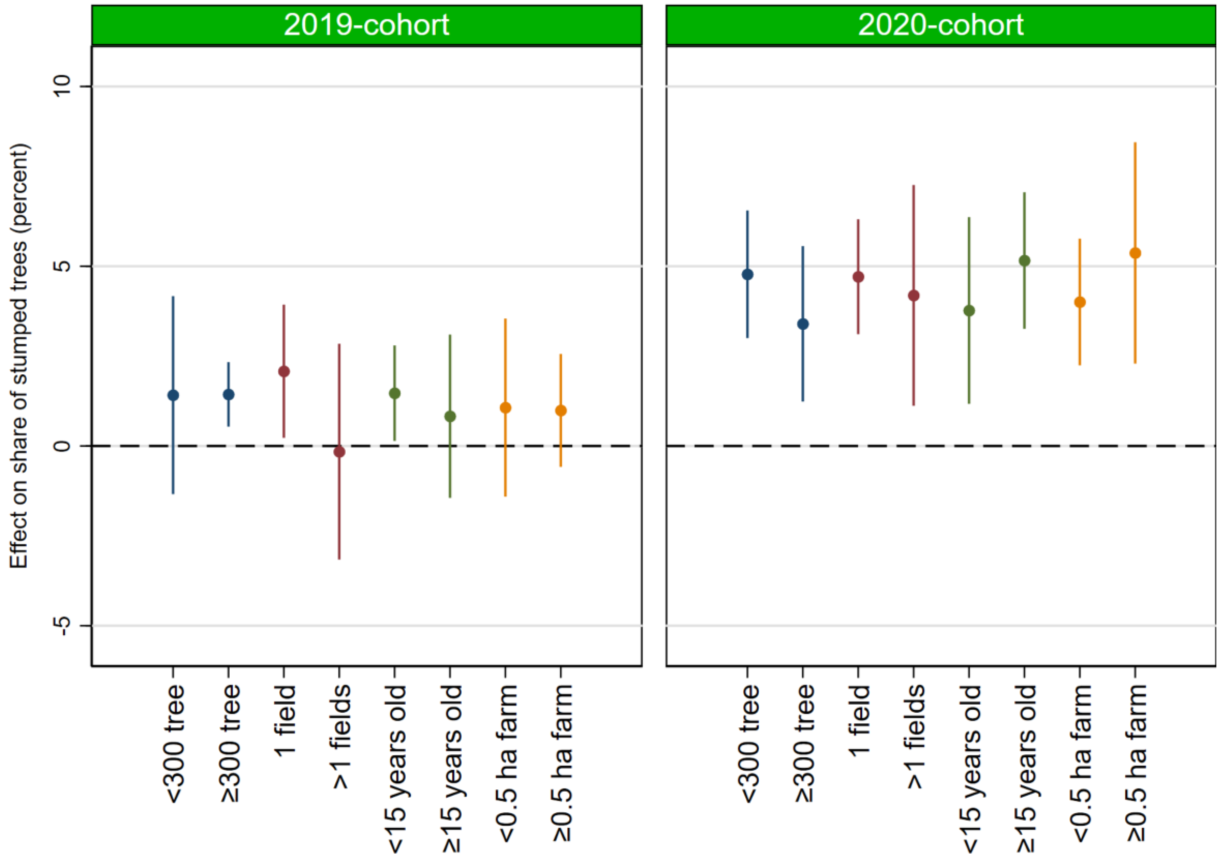
Source: Sidama coffee program baseline and endline surveys collected in April 2021 (2019-cohort) and June 2023 (2020-cohort).

Figure A.2. Estimates of treatment effects heterogeneity on number of coffee trees stumped, by cohort



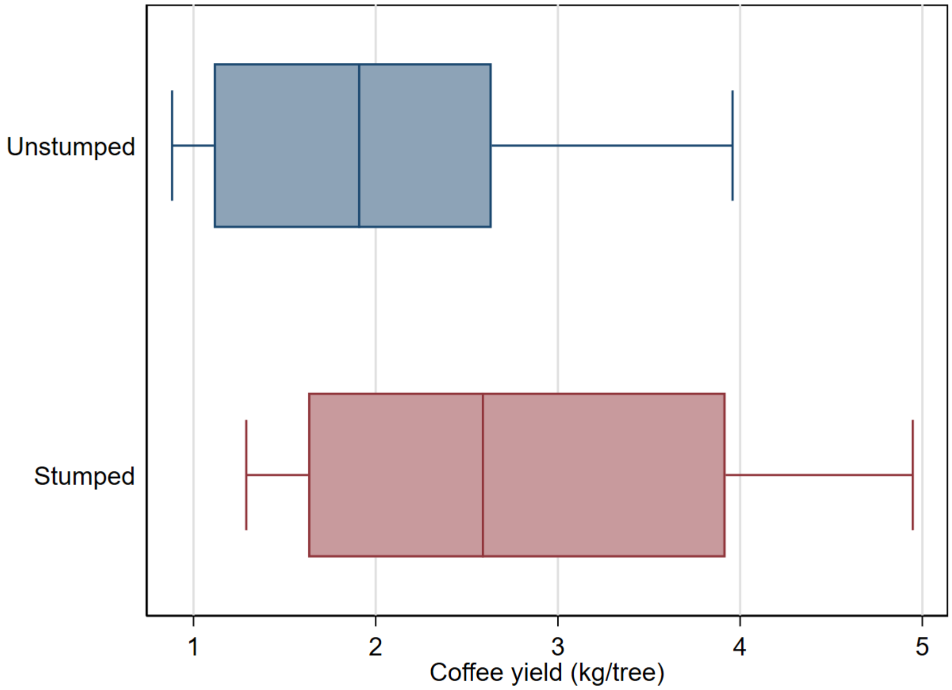
Source: Sidama coffee program baseline and endline surveys collected in April 2021 (2019-cohort) and June 2023 (2020-cohort).

Figure A.3. Estimates of treatment effects heterogeneity on share of coffee trees stumped, by cohort



Source: Sidama coffee program baseline and endline surveys collected in April 2021 (2019-cohort) and June 2023 (2020-cohort).

Figure A.4. Distributions of average coffee tree yield for stumped and unstumped plots



Source: Authors' calculation based on October 2022–January 2023 coffee yield measurement survey.

Figure A.5. Estimates of treatment effects on adoption of best practices, by cohort

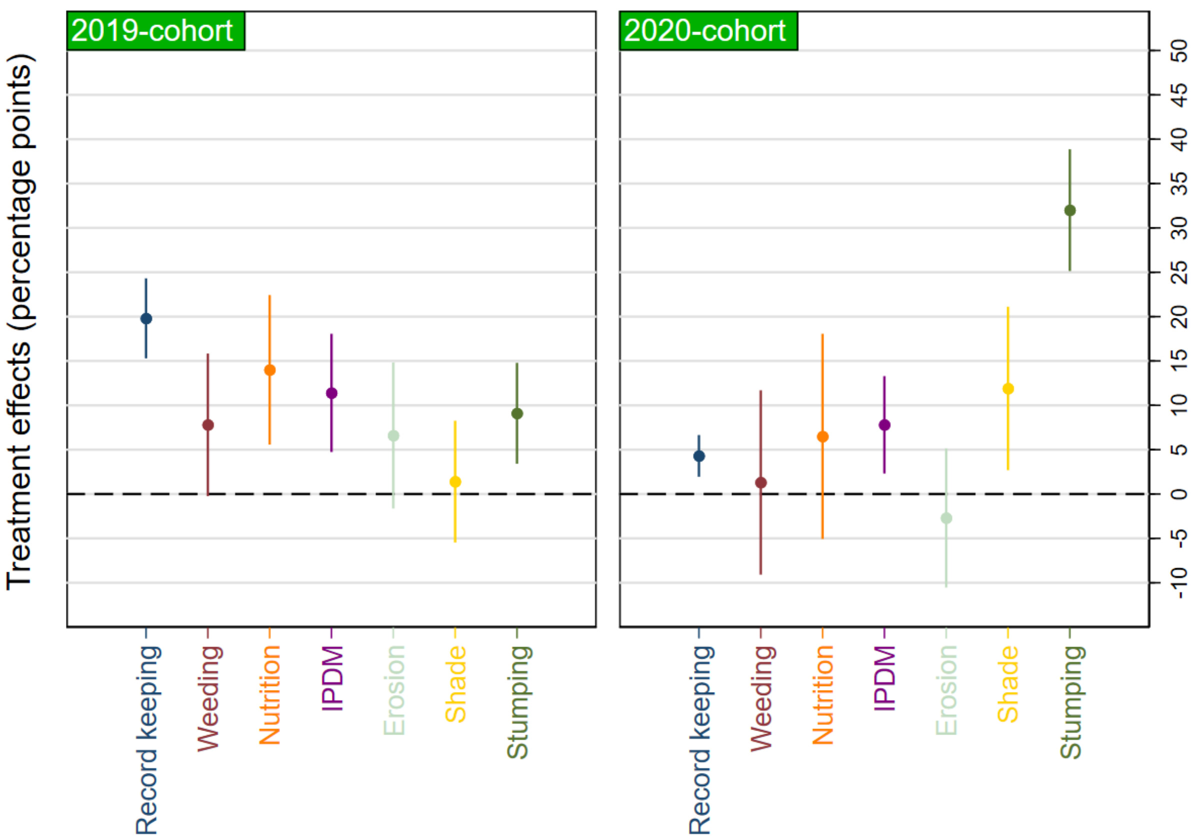


Table A.1. Agronomy knowledge measurement

Topic	Questions	Correct answer(s)
Record Keeping	Can you tell me how to calculate profit or loss?	Income received from coffee sales minus (-) costs of producing the coffee
Composting	How often should you turn a compost heap?	Every month
Intercropping	Can you tell me the BEST crop to plant in your newly planted or stumped coffee as an intercrop?	1. Beans/peas/legumes 2. Ensete/fruit trees 3. Chilies
Weeding	Is it a good practice to weed by digging up the soil under the coffee tree with a Jembe (local term)?	No
Nutrition	How can you feed your coffee trees? If farmers say apply fertilizer, then ask which type of fertilizer?	1. Apply compost or manure (organic fertilizers) 2. Apply man-made fertilizers (e.g., CAN)
Rejuvenation	What can you do with an old unproductive coffee field to make it produce more coffee?	1. Replant with new coffee seedlings 2. Stump the old coffee (to produce new stems)
Sucker Selection	When you stump your coffee new shoots (suckers) will grow. How many new suckers should you keep on each coffee tree?	2–3 suckers
Planting Density	ASK: Can you tell me how many main stems a coffee tree should have if well managed?	1–4 main stems
IPDM	The IPDM knowledge questions are already part of the IPMD best practice.	
Erosion Control	Can you tell me ALL the methods you know to control erosion in your coffee fields?	One or more of the following methods: 1. Plant grasses in rows 2. Use mulch 3. Make water traps or ditches 4. Lay physical barriers like rocks 5. Terrace the field 6. Plant a cover crop - such as beans
Shade Management	Is it good practice to grow your coffee in the full sun, with no shade?	No

Table A.2. Key best practices and adoption rules

Best Practice	Adoption Rules
Business Skills and Record Keeping	Adopted if farmer has a record card **and** can show the record card to the enumerator **and** the card has records of either coffee income, expenses such as hired labor or both.
Weeding	Adopted if farmer: 1. Weeds twice or more per year 2. Has no or few weeds under the canopy 3. Weeds are less than 30cm tall 4. Farmer has not dug under the canopy
Coffee Nutrition	Adopted if nearly all leaves are dark green and healthy **and** at least 1 of the below nutritional products was used on the coffee in the previous 12 months. Fertilizer options: compost/manure, gypsum, lime, worm tea Note: If farmers did not recall compost but compost or manure heap/pit seen in the compost question, it is counted as used.
Rejuvenation/Stumping	Rule I: Adopted if farmer had stumped in **any** of the last 3 years. Rule II: Adopted if farmer had stumped in **any** of the last 3 years, and stumped trees have no more than four main stems for the most recent year in which they stumped.
Integrated Pest and Disease Management	Adopted if farmer knows **any 3 methods** to reduce coffee berry disease (CBD) or white stem borer (WSB). CBD methods: 1. Planting a seedling resistant to CBD 2. Rejuvenating or having young main stems 3. Pruning or keeping canopy open 4. Removing all old coffee berries at end of harvest 5. Using compost or good nutrition to keep trees healthy WSB methods: 1. Stump to reduce the egg laying sites 2. Smooth the rough bark at the base of the tree (with a sack) 3. Kill the stem borer by pushing a wire into the hole made by the borer 4. Uprooting infected coffee trees
Erosion Control	Adopted if **at least 1** erosion control method is seen. Options: Grasses such as vetiver, mulch, water taps, physical barriers (e.g., rocks), terraces, ground cover intercrop.
Shade Management	Adopted if there is 20% shade or more **or** there is less than 20% shade **but** shade trees have been planted in the last 2–3 years.

Table A.3. Best practices adoption rate at baseline (all sample) and endline (non-topic-trained sample)

Best practices	Baseline adoption rates 2019-cohort (Mean)	Baseline adoption rates 2020-cohort (Mean)	Adoption rates of non-topic-trained at endline 2019-cohort (Mean)	Adoption rates of non-topic-trained at endline 2020-cohort (Mean)
Coffee nutrition	0.57	0.42	0.66	0.64
Weeding	0.25	0.20	0.29	0.29
Shade management	0.18	0.47	0.29	0.26
Soil erosion control	0.25	0.12	0.28	0.22
IPDM	0.19	0.02	0.06	0.16
Record keeping	0.001	0.001	0.007	0.01
Rejuvenation	0.04	0.16	0.12	0.14
Stumping survey				
Stumped, dummy	0.04	0.06	0.20	0.16
Stumped, number	1.2	2.1	2.1	4.0
Stumped, share	0.6	1.0	1.0	2.0

Source: Authors' calculation based on the baseline and endline stumping surveys.

Table A.4. Stumping on coffee fields other than the reference plot

	2019-cohort Topic-trained	2019-cohort Untrained	2020-cohort Topic-trained	2020-cohort Untrained
Stumped on other coffee fields			0.38	0.22
			(0.49)	(0.42)
Stumped on other coffee fields, 2019	0.29	0.10	-	-
	(0.31)	(0.46)	-	-
Stumped on other coffee fields, 2020			0.15	0.06
			(0.35)	(0.23)
Stumped on other coffee fields, 2021			0.20	0.10
			(0.40)	(0.30)
Stumped on other coffee fields, 2022	-	-	0.13	0.08
	-	-	(0.34)	(0.28)
# stumped coffee trees, 2019			-	-
			-	-
# stumped coffee trees, 2020			7.09	0.82
			(26.72)	(4.50)
# stumped coffee trees, 2021			7.13	10.40
			(24.32)	(84.36)
# stumped coffee trees, 2022	-	-	8.86	2.08
	-	-	(34.18)	(8.62)
# stumped coffee trees, 2020–22			23.08	13.29
			(64.63)	(84.79)
Observations			310	144

Source: Authors' calculation based on the baseline and endline stumping surveys.
Note: Households with only one coffee field are excluded.

Table A.5. Impact pathways/mechanism (association between training, knowledge, and adoption), by cohort

	2019-Cohort					2020-Cohort				
	Knowledge, PCA		Best Practice adoption			Knowledge, PCA		Best Practice adoption		
			BP, any	BP, >=3	BP, sum			BP, any	BP, >=3	BP, sum
	coef(se)	coef(se)	coef(se)	coef(se)	coef(se)	coef(se)	coef(se)	coef(se)	coef(se)	coef(se)
Attended any training, yes=1	0.203***					0.013				
	(0.076)					(0.121)				
Attended 3 or more trainings, yes=1		0.139**					0.049			
		(0.057)					(0.073)			
Knowledge of BPs, PCA			0.002	0.026***	0.073***			0.047***	0.034***	0.162***
			(0.007)	(0.008)	(0.021)			(0.008)	(0.006)	(0.018)
log (age of household head in years)	0.011	-0.002	0.088***	0.122***	0.392***	0.127	0.128	0.017	0.021	0.120
	(0.119)	(0.120)	(0.029)	(0.041)	(0.098)	(0.130)	(0.129)	(0.029)	(0.040)	(0.097)
log (household size)	0.280***	0.269***	-0.000	0.034	0.123	0.140	0.139	-0.018	-0.006	0.001
	(0.100)	(0.101)	(0.025)	(0.033)	(0.082)	(0.103)	(0.103)	(0.024)	(0.036)	(0.084)
Head attended elementary education	0.378***	0.370***	0.016	0.024	0.080	0.220***	0.219***	-0.004	0.004	-0.011
	(0.085)	(0.085)	(0.021)	(0.028)	(0.069)	(0.072)	(0.072)	(0.018)	(0.023)	(0.058)
Head attended secondary/higher edu.	0.438***	0.427***	0.019	0.022	0.069	0.208*	0.207*	0.037	0.086**	0.294***
	(0.107)	(0.107)	(0.027)	(0.039)	(0.095)	(0.106)	(0.106)	(0.023)	(0.037)	(0.090)
Household is member of cooperative	0.014	0.020	-0.013	0.051**	0.049	0.339***	0.339***	-0.008	-0.002	-0.005
	(0.065)	(0.065)	(0.016)	(0.021)	(0.053)	(0.055)	(0.055)	(0.016)	(0.023)	(0.056)
Livestock owned (in TLU)	-0.020	-0.020	0.000	-0.001	0.003	-0.029*	-0.029	-0.005	-0.004	-0.027*
	(0.020)	(0.020)	(0.005)	(0.007)	(0.017)	(0.018)	(0.018)	(0.004)	(0.006)	(0.016)
Durable asset owned (in PCA)	0.052***	0.050***	-0.009**	0.003	-0.014	0.066***	0.067***	-0.003	-0.001	0.001
	(0.016)	(0.016)	(0.005)	(0.007)	(0.017)	(0.015)	(0.015)	(0.004)	(0.007)	(0.017)
log (age of trees in years)	-0.097***	-0.098***	-0.056***	-0.101***	-0.335***	-0.138***	-0.138***	-0.020***	-0.024**	-0.133***
	(0.035)	(0.035)	(0.009)	(0.015)	(0.036)	(0.025)	(0.025)	(0.007)	(0.011)	(0.026)
log (area of coffee farm in hectares)	-0.301**	-0.262**	-0.004	-0.050	-0.098	-0.581***	-0.578***	0.015	0.088	0.335*
	(0.127)	(0.128)	(0.034)	(0.061)	(0.132)	(0.161)	(0.161)	(0.043)	(0.070)	(0.175)
log (number of coffee trees on plot)	0.150***	0.150***	0.016**	0.037***	0.104***	0.135***	0.133***	0.022***	0.061***	0.168***
	(0.032)	(0.032)	(0.008)	(0.011)	(0.027)	(0.031)	(0.031)	(0.008)	(0.010)	(0.026)
log (distance to a mill that collects coffee)	0.038	0.034	-0.013	0.002	-0.004	0.055	0.055	0.016	0.025	0.060
	(0.037)	(0.037)	(0.010)	(0.014)	(0.033)	(0.051)	(0.051)	(0.011)	(0.016)	(0.040)
log (distance to all-weather road)	0.124***	0.124***	0.045***	0.016	0.097***	-0.116***	-0.116***	0.007	0.011	0.031
	(0.035)	(0.035)	(0.008)	(0.012)	(0.030)	(0.035)	(0.035)	(0.009)	(0.011)	(0.029)
log (distance to woreda capital)	-0.002	0.002	-0.004	-0.004	0.004	-0.094**	-0.096**	-0.022**	-0.019	-0.062*
	(0.028)	(0.027)	(0.009)	(0.010)	(0.027)	(0.040)	(0.040)	(0.011)	(0.016)	(0.035)
Dale woreda	0.265***	0.263***	-0.048***	-0.085***	-0.248***	0.147**	0.153**	-0.059***	-0.043	-0.298***
	(0.057)	(0.057)	(0.015)	(0.022)	(0.052)	(0.064)	(0.063)	(0.021)	(0.028)	(0.066)
Constant	-1.964***	-1.833***	0.603***	-0.210	0.303	-0.773	-0.794	0.836***	-0.122	0.801**
	(0.483)	(0.484)	(0.128)	(0.162)	(0.402)	(0.567)	(0.560)	(0.120)	(0.169)	(0.405)
Number of observations	1,845	1,845	1,845	1,845	1,845	1,862	1,862	1,862	1,862	1,862
R2	0.102	0.100	0.042	0.066	0.093	0.086	0.086	0.066	0.071	0.130
Adjusted R2	0.095	0.093	0.034	0.058	0.086	0.079	0.079	0.058	0.064	0.123

Source: Authors' calculation based on the baseline and endline stumping surveys. *Note*: ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively. BP refers to best practices; PCA refers to principal component analysis.

Table A.6. Balance table (descriptive statistics) for covariates and outcomes, by study arms

Covariates/outcomes	Obs.	(1) Control Mean/SE	Obs.	(2) Farm Support Mean/SE	Obs.	(3) FS + Ambassador Mean/SE	t-test Difference (1)-(2)	t-test Difference (1)-(3)	t-test Difference (2)-(3)
Age of household head in years	342	45.766	327	45.489	344	45.695	0.277	0.071	-0.205
		(0.712)		(0.744)		(0.701)			
Head has attended elementary education (yes=1)	342	0.594	327	0.578	346	0.613	0.016	-0.019	-0.035
		(0.027)		(0.027)		(0.026)			
Head has attended secondary education or higher (yes=1)	342	0.254	327	0.266	346	0.205	-0.012	0.049	0.061*
		(0.024)		(0.024)		(0.022)			
Number of household members	343	5.504	328	5.299	346	5.353	0.206	0.152	-0.054
		(0.095)		(0.103)		(0.092)			
Household is member of coop (yes=1)	343	0.659	328	0.579	346	0.509	0.080**	0.150***	0.071*
		(0.026)		(0.027)		(0.027)			
Livestock owned (in TLU)	343	1.817	328	1.855	346	1.817	-0.038	0.000	0.038
		(0.070)		(0.082)		(0.088)			
Durable asset owned (in PCA)	342	-0.094	327	0.144	346	-0.043	-0.238*	-0.051	0.188
		(0.100)		(0.102)		(0.099)			
Area of total farm in hectares	342	0.814	327	0.802	346	0.788	0.011	0.025	0.014
		(0.029)		(0.033)		(0.032)			
Area of coffee farm in hectares	343	0.402	328	0.362	346	0.373	0.039	0.029	-0.01
		(0.018)		(0.017)		(0.020)			
Area of BP coffee farm in hectares	343	0.278	328	0.234	346	0.271	0.044***	0.007	-0.037**
		(0.011)		(0.010)		(0.015)			
Coffee nutrition	343	0.65	328	0.668	346	0.702	-0.018	-0.052	-0.035
		(0.026)		(0.026)		(0.025)			
Weeding	343	0.157	328	0.201	346	0.251	-0.044	-0.094***	-0.05
		(0.020)		(0.022)		(0.023)			
Shade management	343	0.373	328	0.375	346	0.321	-0.002	0.052	0.054
		(0.026)		(0.027)		(0.025)			
Soil erosion control	343	0.122	328	0.177	346	0.263	-0.054**	-0.141***	-0.086***
		(0.018)		(0.021)		(0.024)			
IPDM	343	0.19	328	0.143	346	0.09	0.046	0.100***	0.054**
		(0.021)		(0.019)		(0.015)			
Record keeping	343	0.017	328	0.076	346	0.026	-0.059***	-0.009	0.050***
		(0.007)		(0.015)		(0.009)			
Rejuvenation/stumping	343	0.248	328	0.265	346	0.228	-0.017	0.019	0.037
		(0.023)		(0.024)		(0.023)			

Source: Authors' calculation based on August 2021 (and July 2022) farm support and ambassador assessment surveys. *Note*: ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively. BP refers to best practices; PCA refers to principal component analysis.

Table A.7. Estimates of the impacts of farm support and farm ambassador (any treatment) on best practices adoption

	Coffee nutrition	Weeding	Shade	Erosion control	IPDM	Record keeping	Stumping
Any treatment	0.024	0.071	-0.037	0.103**	-0.068**	0.040**	0.019
	(0.047)	(0.077)	(0.047)	(0.042)	(0.025)	(0.015)	(0.035)
log (age of household head in years)	-0.150**	0.013	-0.030	-0.052	0.042	-0.034*	-0.042
	(0.056)	(0.060)	(0.066)	(0.048)	(0.048)	(0.020)	(0.060)
log (household size)	0.043	0.014	-0.065	0.038	0.101**	0.033	0.146***
	(0.052)	(0.042)	(0.061)	(0.035)	(0.039)	(0.020)	(0.037)
Head has attended elementary education	0.095**	-0.082**	-0.014	0.016	0.042	0.011	-0.012
	(0.039)	(0.037)	(0.045)	(0.031)	(0.042)	(0.016)	(0.030)
Head has attended secondary education or higher	0.059	-0.038	-0.030	0.048	0.070	0.002	0.083**
	(0.041)	(0.038)	(0.055)	(0.041)	(0.044)	(0.018)	(0.039)
Household is member of cooperative	-0.017	0.108**	-0.060*	0.044	-0.060*	0.019	0.066**
	(0.042)	(0.040)	(0.031)	(0.036)	(0.030)	(0.012)	(0.030)
Livestock owned (in TLU)	-0.005	0.004	0.011	0.003	0.004	-0.007*	0.011
	(0.014)	(0.012)	(0.011)	(0.008)	(0.009)	(0.004)	(0.012)
Durable asset owned (in PCA)	0.016	0.009	0.016	0.008	0.001	0.000	0.005
	(0.010)	(0.011)	(0.010)	(0.013)	(0.008)	(0.003)	(0.010)
log (area of coffee farm in hectares)	0.142	-0.270***	0.246**	-0.029	-0.052	0.025	0.199***
	(0.089)	(0.079)	(0.102)	(0.072)	(0.069)	(0.030)	(0.072)
Dale woreda	-0.151***	-0.024	-0.041	-0.005	0.139***	0.043**	0.039
	(0.052)	(0.068)	(0.043)	(0.042)	(0.026)	(0.019)	(0.037)
Constant	1.117***	0.160	0.583**	0.206	-0.209	0.053	-0.017
	(0.221)	(0.255)	(0.276)	(0.193)	(0.170)	(0.094)	(0.233)
Control mean	0.65	0.16	0.37	0.12	0.19	0.02	0.25
Number of observations	1,012	1,012	1,012	1,012	1,012	1,012	1,012
R2	0.048	0.038	0.022	0.025	0.060	0.029	0.062
Adjusted R2	0.038	0.029	0.013	0.016	0.051	0.019	0.052

Source: Authors' calculation based on August 2021 and July 2022 farm support and ambassador assessment surveys. *Note*: ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively. PCA refers to principal component analysis.

Table A.8. Estimates of the impacts of coffee rejuvenation training and stumping incentives on adoption and intensity of coffee stumping (for any incentive threshold (Panel A) and for relatively lower vs. higher incentive thresholds (Panel B))

	Stumping adoption		Number of stumped coffee trees		Share of stumped coffee trees	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Any incentive threshold (Groups 1–4)						
Rejuvenation training (2020–2022, yes=1)	0.281***	0.225***	10.776***	3.539	2.757*	2.892*
	(0.078)	(0.084)	(2.679)	(3.783)	(1.501)	(1.729)
Stumping incentive	-0.015	-0.034	2.130	1.204	-0.128	-0.444
	(0.072)	(0.079)	(1.537)	(3.329)	(1.384)	(1.607)
Rejuvenation training *Stumping incentive	0.017	0.034	3.140	3.536	2.275	2.580
	(0.085)	(0.091)	(3.458)	(4.262)	(1.692)	(1.867)
Baseline value	Yes	Yes	Yes	Yes	Yes	Yes
Other controls	No	Yes	No	Yes	No	Yes
Constant	0.152**	-0.731***	1.280	-64.656***	1.934	-8.025
	(0.067)	(0.273)	(1.119)	(22.925)	(1.285)	(7.057)
Number of observations	940	940	940	940	940	940
R2	0.073	0.116	0.068	0.185	0.043	0.068
Adjusted R2	0.069	0.097	0.064	0.167	0.039	0.048
Panel B: Lower (Groups 1 and 2) vs. higher (Groups 3 and 4) thresholds						
Rejuvenation training (2020–2022, yes=1)	0.281***	0.228***	10.789***	3.804	2.753*	2.945*
	(0.078)	(0.084)	(2.683)	(3.778)	(1.503)	(1.731)
Groups 1 & 2	-0.070	-0.077	0.589	1.211	-1.524	-1.856
	(0.077)	(0.083)	(2.363)	(4.001)	(1.372)	(1.648)
Groups 3 & 4	0.014	-0.005	2.948*	1.719	0.606	0.437
	(0.076)	(0.083)	(1.638)	(3.502)	(1.491)	(1.705)
Rejuvenation training *Groups 1 & 2	0.112	0.120	8.550*	7.500	4.615***	4.882**
	(0.092)	(0.095)	(4.526)	(5.013)	(1.779)	(1.931)
Rejuvenation training *Groups 3 & 4	-0.058	-0.042	-2.253	-1.388	0.432	0.689
	(0.091)	(0.097)	(3.774)	(4.678)	(1.860)	(2.088)
Baseline value	Yes	Yes	Yes	Yes	Yes	Yes
Other controls	No	Yes	No	Yes	No	Yes
Constant	0.152**	-0.702**	1.285	-62.647***	1.941	-7.292
	(0.067)	(0.272)	(1.119)	(22.434)	(1.287)	(6.984)
Number of observations	940	940	940	940	940	940
R2	0.079	0.122	0.075	0.191	0.048	0.073
Adjusted R2	0.073	0.101	0.069	0.172	0.042	0.051

Source: Authors' calculation based on 2020 and 2022 baseline and stumping surveys.
Note: ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively.

Table A.9. Estimates of the impacts of coffee rejuvenation/stumping on coffee harvest

	Dependent variable: log(yield)			
	(1)	(2)	(3)	(4)
Rejuvenated plot (yes=1)	0.492***	0.425***	0.295**	0.265**
	(0.038)	(0.040)	(0.134)	(0.117)
Number of coffee trees		0.030***	0.029***	0.020***
		(0.006)	(0.005)	(0.005)
Age of coffee trees			-0.003	0.001
			(0.012)	(0.009)
Height of coffee trees			-0.082	-0.126
			(0.091)	(0.076)
Mulch seen on the plot (yes=1)			0.101	0.117
			(0.183)	(0.162)
Sufficient weeding (yes=1)			0.102	-0.028
			(0.102)	(0.097)
Sufficient shade (yes=1)			0.371***	0.281***
			(0.113)	(0.102)
Application of compost (yes=1)			0.298***	0.256**
			(0.108)	(0.102)
Dale woreda				0.524***
				(0.092)
Constant	3.626***	2.891***	3.024***	3.204***
	(0.070)	(0.168)	(0.446)	(0.363)
Number of observations	222	222	222	222
R2	0.115	0.239	0.340	0.442
Adjusted R2	0.111	0.232	0.316	0.419

Source: Authors' calculation based on October 2022–January 2023 coffee yield measurement survey.
Note: ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively.

Table A.10. Estimates of treatment effects on the number of best practices adopted, by cohort

	2019-cohort			2020-cohort		
	BP, any coef/se	BP, >=4 coef/se	BP, sum coef/se	BP, any coef/se	BP, >=4 coef/se	BP, sum coef/se
Attended 4 or more trainings, yes=1	0.018	-0.012	0.024	0.009	-0.035**	-0.032
	(0.025)	(0.012)	(0.067)	(0.032)	(0.014)	(0.082)
Endline, yes=1	0.142***	-0.008	0.308***	0.115***	0.022	0.494***
	(0.021)	(0.012)	(0.063)	(0.036)	(0.021)	(0.098)
Interaction: Endline*Attended 4 or more trainings	0.001	0.122***	0.517***	0.025	0.107***	0.421***
	(0.028)	(0.022)	(0.090)	(0.039)	(0.025)	(0.110)
log(age of household head in years)	0.028	0.021	0.114	-0.024	0.009	-0.148
	(0.029)	(0.020)	(0.094)	(0.030)	(0.022)	(0.095)
log(household size)	-0.016	0.022**	0.279***	0.000	0.034**	0.097
	(0.014)	(0.009)	(0.047)	(0.025)	(0.017)	(0.084)
Head has attended elementary education	0.022	0.009	0.080	0.005	0.012	0.011
	(0.020)	(0.012)	(0.066)	(0.018)	(0.013)	(0.056)
Head has attended secondary education or higher	0.017	0.019	0.060	0.037	0.063***	0.269***
	(0.026)	(0.019)	(0.089)	(0.023)	(0.023)	(0.086)
Household is member of cooperative	-0.024	0.009	0.007	0.002	0.005	0.015
	(0.016)	(0.011)	(0.051)	(0.016)	(0.014)	(0.054)
Livestock owned (in TLU)	-0.001	0.001	-0.005	-0.006	-0.006*	-0.029*
	(0.004)	(0.004)	(0.016)	(0.004)	(0.004)	(0.015)
Durable asset owned (in PCA)	-0.007	0.001	-0.009	0.001	-0.004	0.012
	(0.004)	(0.004)	(0.016)	(0.004)	(0.003)	(0.016)
log(age of trees in years)	-0.013	-0.021**	-0.158***	-0.009	-0.002	-0.046*
	(0.010)	(0.010)	(0.038)	(0.007)	(0.007)	(0.025)
log(area of coffee farm in hectares)	0.002	-0.031	-0.048	0.015	0.099**	0.409**
	(0.034)	(0.026)	(0.126)	(0.041)	(0.040)	(0.172)
log(number of coffee trees on plot)	0.013*	0.015**	0.083***	0.022***	0.018***	0.146***
	(0.007)	(0.006)	(0.025)	(0.008)	(0.006)	(0.025)
log(distance to a mill that collects coffee)	-0.013	0.008	0.010	0.018	0.001	0.070*
	(0.009)	(0.007)	(0.031)	(0.011)	(0.010)	(0.039)
log(distance to all-weather road)	0.046***	-0.008	0.103***	-0.000	0.001	0.005
	(0.008)	(0.006)	(0.029)	(0.009)	(0.008)	(0.029)
log(distance to woreda capital)	-0.002	0.001	0.002	-0.027**	0.005	-0.087**
	(0.009)	(0.005)	(0.025)	(0.011)	(0.008)	(0.035)
Dale woreda	-0.043***	-0.009	-0.212***	-0.047**	-0.028*	-0.229***
	(0.014)	(0.011)	(0.049)	(0.021)	(0.015)	(0.067)
Constant	0.670***	-0.117	0.376	0.877***	-0.187*	1.224***
	(0.123)	(0.076)	(0.373)	(0.124)	(0.095)	(0.398)
Number of observations	1,904	1,904	1,904	1,862	1,862	1,862
R2	0.086	0.066	0.178	0.077	0.088	0.231
Adjusted R2	0.077	0.058	0.171	0.069	0.079	0.224

Source: Sidama coffee program baseline and endline surveys collected in April 2021 (2019-cohort) and June 2023 (2020-cohort).

Note: ***, **, * denotes statistical significance at 1%, 5%, and 10% level.