Promoting adoption of sustainable land management technologies by women and couples in rural Ethiopia: Evidence from a randomized trial

Pre-analysis plan

December 21, 2023

Contents

1. Study objectives

1.1. Motivation and research questions

Sustainable land management (SLM) technologies including composting, agroforestry and intercropping are widely promoted as strategies to enhance resilience against adverse climatic and environmental conditions by improving soil fertility and water retention, reducing erosion, and storing additional carbon in the soil (Branca et al 2013). In Ethiopia, policy interest in enhancing sustainable land management is high, but take-up of SLM practices remains low (Teklewood et al. 2013). A number of previous interventions have focused on planting trees on communal land as a part of land restoration or watershed protection efforts, but little is known about the benefits of these programs (Fikreyesus et al. 2022). More broadly, the experimental literature analyzing strategies to encourage take-up of SLM-related technologies in low- and middle-income countries remains extremely limited (Haregeweyn et al. 2023).

The objective of this randomized controlled trial is to evaluate a bundled intervention providing training and inputs (tree seedlings and vegetable gardening inputs) to encourage rural Ethiopian households to adopt three complementary SLM practices: tree planting, composting, and home gardening. The households are all part of Ethiopia's main social safety net program (the Productive Safety Net Program or PSNP) and thus are characterized by high levels of poverty and vulnerability to shocks. The long-term goals of adoption include the enhancement of soil fertility, the reduction of erosion and increased resiliency to adverse weather. Formative work conducted by this research team suggests that at the household level, tree planting is often constrained by shortages of locally adapted, quality seedlings. Compost and home gardening technologies may be more accessible, but limited knowledge and limited labor supply continue to pose constraints (Tefera et al 2023).

In addition, previous evidence suggests that climate adaptation strategies differ for women and men (Ngigi et al. 2017), and women's adoption of such strategies may be more limited due to reduced labor availability, limited access to required inputs, informational barriers, and restrictive social norms (Jost et al. 2016, Ahmed and Kiester 2021). Accordingly, we also seek to evaluate two different targeting strategies – training women alone, or training men and women jointly – designed to encourage women's participation in the decision-making around and implementation of sustainable land management technologies. Comparing the relative impacts of the two treatment arms allows us to test whether men's engagement increases the probability of adopting SLM practices, and whether this engagement affects patterns of intra-household task sharing and equality in decision-making.[1]

More specifically, the trial addresses the following research questions:

- Does a sustainable land management intervention providing training and a package of inputs result in take-up of SLM technologies in a sample of poor PSNP households in rural Ethiopia?
- Does this effect differ when women are solely targeted for inclusion, or when they are jointly targeted with their husbands and trained in adopting the practices collaboratively?

[1] Other benefits of SLM technologies including increased tree cover and reduced erosion are challenging to measure at the household level, particularly on a short time scale, and we don't expect to quantify these benefits in this trial; we will be able to measure whether there are any direct benefits from the establishment of home gardens in terms of consumption or dietary diversity.

    - Are there additional effects of the women's only or the couples' training on intrahousehold decision-making, task sharing, and perceptions of climate risks?
    - Is adoption higher (particularly in the couples' arm) among households characterized by a higher level of spousal cooperation at baseline?
- Is adoption of SLM technologies higher among households reporting higher perception of climate risks at baseline; or among households reporting different time preferences (more patient) or different risk preferences (more averse to risk) at baseline?

1.2. Literature

Widespread adoption of sustainable land management practices is crucial for reducing land degradation, restoring degraded lands, and increasing agricultural productivity in low- and middle-income countries, particularly in sub-Saharan Africa (FAO 2019, Shiferaw et al. 2009). However, given that the aggregate benefits from these practices generally meaningfully exceed the private benefits, a low perceived benefit to cost ratio at the household level is a major constraint on adoption (Jack 2011, Beaman and Dillon 2018), as is lack of knowledge (Conley and Udry 2010), but evidence around effective strategies remains scarce (Haregeweyn et al. 2023). Similarly, high-quality evidence on the household-level benefits from SLM technologies is extremely thin in low and middle-income countries (Pretty et al. 2018).

In the existing literature, an intervention in Niger providing training in constructing demilunes (designed to reduce soil degradation) had large positive effects on adoption of demilunes as well as agricultural output (Aker and Jack 2021). In Burkina Faso, Adjognon et al. (2022) show that a cascade training program complemented by financial incentives increased uptake of SLM practices and yielded higher crop productivity and agricultural income within a year. In Malawi, an auction mechanism providing payments for tree maintenance was effective in increasing tree survival (Jack 2013), and cash payments for conservation behaviors, often summarized as payments for ecosystem services (PES), have also been effective in inducing forest and water conservation in Uganda (Jayachandran 2017). At a more aggregate level, Ethiopia's Sustainable Land Management Project had a significant positive effect on gross primary output in treated areas that were affected by severe droughts, as compared to untreated localities facing drought (Constenla-Villoslada et al. 2022), and there is some evidence that the PSNP itself has increased tree cover in target districts (Hirvonen et al. 2022).

The choices made by households around the adoption of SLM technologies may also be shaped by their attitudes around risk and their willingness to incur upfront costs for long-term benefits. On one hand, it is well established that farmers' aversion to risk hinders their decisions to adopt new agricultural technologies (Feder et al. 1985, Zilberman et al. 2012). On the other hand, technologies conserving soil and water generally have risk reduction properties, allowing households to smooth production across years characterized by different weather realizations and reduce reliance on external inputs (Shiferaw et al. 2009, Asfaw et al. 2014). While there is a growing body of literature examining how climate risk specifically affects adoption of SLM technologies (Kassie at al. 2008, Asfaw et al. 2018, Asfaw et al. 2014), empirical evidence incorporating elicited risk preferences is limited. In Ethiopia, Wossen et al. (2014) use a panel sample to show that a composite measure of SLM practice adoption is associated with more risk aversion, while Bezabih et al. (2012) show that higher risk aversion is likely to lead to more crop diversification, a practice related to SLM. By contrast, in China, farmers' level of risk aversion was associated both positively and negatively with different adaptation strategies vis-à-vis local climate

change (Jin et al. 2015) and in Ethiopia, Teklewood et al. (2011) find that high degree of risk aversion decreases the probability of adopting soil conservation.

With respect to time preference, households that are more patient are also more likely to adopt practices that have short-term costs but benefits primarily in the medium- to long-term (Shiferaw et al. 2009). In Ethiopia, a previous study found a correlation between high rates of time preference (present bias) and adoption of conservation technologies (Shiferaw and Holden 1996). In China, however, the discount rate was not found to be significantly predictive of adoption of practices designed to mitigate against an upward trend in precipitation (Ding et al. 2021).

Understanding the gendered patterns of adoption of SLM practices is also critical in stimulating overall adoption (Perez et al. 2015). Previous literature has demonstrated that women use soil and water conservation practices at much lower rates than men, primarily due to their limited access to labor and inputs (Jost et al. 2016, Meinzen-Dick et al. 2019), and information provided about sustainable land management via extension services does not reach female farmers as effectively as male farmers (Kondylis et al. 2016). Households in which land is managed by women are also more negatively affected by weather shocks in Malawi, a pattern that may reflect women's relatively weaker land tenure and inability to make investments in soil and water conservation (Asfaw and Maggio 2018). In Ethiopia specifically, evidence suggests women are less likely to practice agroforestry due to poor knowledge about land rights (Quisumbing and Kumar 2014), and their participation in community institutions like watershed committees is low (Kato et al. 2021).

Gendered climate change perceptions may also influence adaptive behaviors. Ngigi et al. (2017) finds that female spouses, due to their reliance on climate-sensitive activities, exhibit heightened awareness of climatic risks impacting their families. In a complementary study, Ginbo and Hansoon (2023) analyzes the impact of spouses' climate risk perceptions on climate change adaptation strategies using data from Kenya, Uganda, and Senegal and concludes that higher risk perceptions are associated with a higher probability of adopting soil and water conservation strategies.

However, interventions designed to increase uptake of climate-sensitive interventions can exacerbate preexisting gender equalities if not carefully designed to increase women's influence in decision-making and access to information (Huyer et al. 2021). In Ethiopia, Cholo et al. (2020) find that the application of land management practices to address climate change and variability in weather increases women's working hours, while male working hours are unaffected. A program that established watersheds promoting SLM practices – including soil and water conservation, mulching and manuring – evaluated by Kato et al. (2021) and Kato et al. (2022) significantly increased adoption of SLM practices only on male-owned and jointly-owned plots as compared to female-owned plots. Our analysis of the relative effectiveness of training women alone vis-à-vis couples jointly is motivated in part by the importance of identifying strategies to ensure that women share in the decision-making process around adapting SLM practices and the benefits of those practices, without shouldering an undue burden of the costs.

In comparing the effectiveness of providing training to women only versus couples, we also contribute to a broader recent literature evaluating information provision and training targeted at different household members. In an experiment conducted in Uganda, Lecoutere et al. (2023) conclude that targeting a female co-head alone with agricultural extension services (as opposed to jointly targeting both co-heads) is the most effective strategy to increase women's knowledge, role in agricultural decision-making, and subsequent adoption of recommended practices. However, joint participation of

co-heads in extension was found to be more effective in encouraging adoption of soil fertility management practices (vis-à-vis participation by the male or female spouse alone) in the Democratic Republic of Congo (Lambrecht et al. 2016). Evidence from Ethiopia suggests that targeting women directly with an intervention encompassing agricultural training and a financial transfer has no effect on women's adoption of new agricultural technologies (Bedi et al. 2023); targeting men only increases take-up by both men and women, and targeting both spouses increases take-up only by men. In Cote d'Ivoire, including both spouses in a training around rubber production led to significant increases in income when compared to a training including men only (Donald et al. 2022).

2. Evaluation design

2.1. Kebele & participant selection

The study is a cluster-randomized control trial including 95 kebeles (sub-districts) in 16 woredas (districts) sampled from the geographic area served by SPIR II in Amhara and Oromia Regions in Ethiopia. SPIR II (Strengthen Productive Safety Net Program Institutions and Resilience II) is a multifaceted intervention that seeks to sustain nutrition security, reduce risks to livelihoods, and strengthen social safety nets through its support of the government's Productive Safety Net Program (PSNP), one of the largest social safety net programs in sub-Saharan Africa. The PSNP provides food or cash transfers targeted to poor households in the form of payments for seasonal labor on public works or as direct support to households, and has been shown to reduce household food insecurity and increase asset holdings (Berhane et al., 2014; Hoddinott et al., 2012). Funded by USAID's Bureau for Humanitarian Assistance (BHA) and in close collaboration with the Government of Ethiopia, World Vision leads the implementation of SPIR II, in partnership with ORDA Ethiopia and CARE.

The kebeles were selected from the broader frame of SPIR II communities, prioritizing kebeles that had not previously been included in any other large-scale impact evaluations. The final choice of kebeles was determined by implementing partner staff based on the suitability of the chosen technologies in the prevailing local agroclimatic conditions, as well as the availability of water.

Following the identification of the sample kebeles, the evaluation sampled 1,900 households (20 households from each kebele) based on the following criteria.

- Households were required to include a cohabiting couple of prime working age (18-60 years, the eligible age range for participation in PSNP public works);
- Households were required to own or operate at least some land.[2]

(Households previously included in any other randomized controlled trials conducted by the SPIR research team were ineligible. At the point of study launch, IFPRI was conducting two other large-scale trials including PSNP beneficiary households in the same regions.)

To construct the sample, the sample frame of PSNP beneficiary households was randomly ordered at the kebele level. The sampling frame was matched to the sample lists of previous trials, and households who

[2] A household operating land is defined as a household that manages the land and is empowered to make decisions around the land's use.

were part of an existing study sample were excluded. The survey team then visited sample households in order, screening for eligibility. If the household was deemed to fit all pre-specified criteria, the household entered the sample, the baseline survey was conducted, and (in treatment communities) the household was invited to participate in the training and receive inputs.

2.2. Randomization

Kebeles were randomized into three arms prior to the baseline survey. The arms are as follows:

1) T1 – Bundled training intervention rolled out to women alone;
2) T2 – Bundled training intervention rolled out to couples, with the addition of a joint planning exercise;
3) T3 – Control

Note that all households in all three arms (including the control arm) were beneficiaries of the PSNP and thus eligible for the cash and food payments provided through the PSNP.[3]

The randomization was stratified by woreda and by a binary variable equal to one if a kebele was part of the sample for the other two large-scale trials described above.

2.3. Intervention design

The main intervention was a three-day training (four days in treatment arm T2) conducted in June 2023 that provided an overview of three main sustainable land management practices: tree planting, composting, and establishing a home garden. First, the training covered timely pit preparation, correct tree planting, maintenance, and long-term benefits of locally adapted fruit trees and other multi-purpose trees, as well as related relevant climate smart practices and land management techniques. Second, the training provided an overview of composting practices: collecting green grasses, animal manure, and other inputs for composting, preparing the compost, and applying it to planted trees and vegetables. Third, the training outlined how to establish a vegetable garden following intercropping principles and how to effectively maintain a garden. The curriculum was based on an extension strategy developed by the Ethiopian government.

The trainings were rolled out at existing kebele-level farmer training centers or model farmer demonstration sites. SPIR staff contacted all sample households in kebeles assigned to T1 or T2 to provide an invitation to the training. However, in the women's only arm, other male members of the household could not substitute for the target woman in attending the training.[4] Women were allowed to bring their children with them to the training site in order for them to facilitate their participation.

[3] The PSNP provides seasonal monthly cash and food payments for 6 months to poor households participating in public works (80% of beneficiaries) or as direct support to labor-scarce poor households (20%). In addition, pregnant women receive cash and food payments as temporary direct support for 12 months after the pregnancy is registered.

[4] Women who are female heads of households were allowed to nominate another female family member to join the training. However, there were very few female heads of household in the sample given that all households by definition included a cohabiting couple.

Following the completion of training, all participants in T1 and T2 received 4-8 free tree seedlings and seeds and tools for vegetable gardening.[5] Seedlings were raised at SPIR-II supported government nurseries and distributed by SPIR implementing organizations in July 2023, roughly four weeks post-training, at a point when participants had prepared their planting sites.

In the treatment arm targeting couples (T2), the fourth additional day of training was used primarily to conduct a joint planning exercise that required the participating couples to jointly develop a workplan for tree maintenance, composting and home gardening over the next six to twelve months, and devise the associated labor allocation. The participants were provided with a planning worksheet designed to be accessible to both literate and non-literate participants; the worksheet included a graphical depiction of all the required phases of work associated with adoption of each SLM technology, and allowed participants to indicate who would lead in each phase, or if they would execute a particular phase jointly. (A copy of the planning sheet is provided in the Appendix.) The participants then participated in a brief facilitated planning exercise led by the training facilitator and had an opportunity to jointly fill out their plan, assisted as needed by the facilitator. The spouses retained the document to allow them to refer to it over the study period.

In the women only arm (T1), participants also received a simpler card that provided the list of tasks required to implement the SLM practices of interest, ensuring that participants in both treatment arms had access to the same information. However, the card provided in T1 had no columns for assigning tasks, and no planning exercise was conducted in the training.

2.4. Data collection

The fieldwork for the baseline data collection took place between May 24 and June 29, 2023, and was conducted by EconInsight. Six teams of six enumerators each were employed for the survey. Prior to the fieldwork, the 36 enumerators completed a four-day classroom-based training on the questionnaire, a one-day training on the implementation of the cooperation game, and a two-day pilot of the whole survey. Key modules in the baseline survey (administered only to the primary female) included knowledge and perceptions of climate risk and SLM practices, current use of SLM practices, agriculture, household food security, and assets; the female respondent also participated in incentivized games to assess time and risk preference.

The incentivized game around time preference entailed a multiple price list in which the respondent made choices across payments of varying magnitude today vis-à-vis two weeks; the incentivized game around risk preference entailed a similar set of choices comparing a computerized lottery with a random payout vis-à-vis a fixed payment. All respondents participated in both incentivized modules, but they were informed ex ante that they would be paid based on their choices in one randomly chosen module (time or risk preference).[6] On average, respondents could earn 50 birr through their choices in these

[5] For tools, households received a shovel, a watering can, and a three-finger hoe; for seeds, most households received carrot, Swiss chard, Ethiopian kale, or beetroot seeds, with fewer receiving additional seeds for cabbage, onion, or peppers, for a total of 60-80 vegetables on average; for trees, households mostly received mango, avocado, or papaya tree seedlings.

[6] For those respondents who were paid on the basis of their choices in the time preference module and who chose a payment in two weeks, either an enumerator or a trusted SPIR staff member re-visited the household to make the second payment. All payments were made in person, in cash.

two games, supplementing a base payment of 50 birr provided to all respondents to compensate them for the time required to participate in the survey.

Following the implementation of the household-level survey, a second lab-in-the-field exercise was then convened in each kebele with both spouses from sampled households; the objective was to collect experimental measures of intrahousehold (spousal) cooperation. The (female) respondents were informed of the experimental session and were invited to attend jointly with their spouses; they were advised each individual would earn a minimum of 100 birr for attending, and an average of 300 birr (each). However, couples could only be eligible for the payments if they attended jointly. Two experimental sessions were conducted in each kebele, allowing for an average of 10 couples in each session; in the sessions, men and women were seated separately and guided by a same-gender enumerator to specify their willingness to contribute/donate in the public goods and the dictator game when played vis-à-vis their spouse and vis-à-vis a hypothetical stranger of the same as well as opposite gender. (The experimental choices were also preceded by a detailed explanation of the games to ensure adequate comprehension.) Following the respondents' specification of their choices in these games, one of the games played was randomly chosen as the basis for payment and payments were immediately disbursed in cash. The full experimental protocol is provided as an Appendix.[7]

As described in the sampling section, the enumerators utilized a sample frame that consisted of all PSNP households that are not part of other SPIR II studies. In total, 6,983 households were visited by the survey team, of which 4,084 were successfully located and screened for two criteria: whether they owned or operated any land, and whether there was a cohabiting couple. 3.2% of households did not meet the first criteria, while 51.9% did not meet the second criteria. The non-cohabitation rate was particularly high in this sample (and much higher than projected), and feedback from the survey team indicated that this was linked to the widespread recent insecurity in Ethiopia linked to civil conflict (particularly in Amhara). This insecurity has led a large number of men to separate from their households due to displacement or violence or in order to participate in civil defense, in addition to potential relocation to cope with weather and other livelihood shocks.

The endline survey for this evaluation is planned for 12 months post-baseline, in May and June 2024.

3. Empirical analysis

3.1. Outcomes of interest

Table 1 summarizes the primary and secondary outcomes of interest for the trial and denotes whether those variables have been measured at baseline.

Table 1: Primary and secondary outcomes of interest

	Outcome	Definition	Base-line	End-line

[7] In determining payment, each respondent was randomly assigned to be paid on the basis of one of four games: the dictator and public goods game with his/her spouse, or the dictator and public goods game with a stranger of the opposite gender. Respondents were not informed about what game was the basis for payment. This accordingly preserves confidentiality around game decisions within a couple (respondents could not infer what choices were made by their spouses in the game in which they played vis-à-vis their spouse).

PRIMARY	**Adoption of trees**	Binary and continuous variable for any trees (number of trees) planted on household-operated land	X	X
	Adoption of home gardening	Binary variable for any home garden on household-operated land	X	X
	Adoption of compost	Binary variable for any compost heap on household-operated land	X	X
	Female engagement in SLM	Number of SLM-related tasks in which the female spouse is engaged[8]	X	X
SECONDARY	**Tree health**	Index constructed from two variables: tree height, basal stem diameter		X
	Intensity of adoption of home gardening	Quantity of vegetables harvested		X
	Intensity of adoption of compost	Amount of compost applied so far		X
	Intrahousehold decision-making around SLM	Index of SLM-related decision-making, reported by both men and women		X
	Intrahousehold decision-making	Index of household decision-making, reported by both men and women [9]	X	X
	SLM knowledge	Knowledge score around SLM practices	X	X
	Climate risk perception	Index capturing household perception of climate risks[10]		X

3.2. Power calculations

We conducted power calculations prior to the survey launch using data from a previous survey conducted with a sample of PSNP households in the same regions in 2021, as summarized in Table 2a. Note that the choice of variables for these power calculations was driven by data availability, and thus the variables reported are not directly related to our primary outcomes in this evaluation.

In Table 2b we report power calculations that we re-estimated using baseline data for our primary outcomes of interest. In general, the trial has the statistical power to detect increases of around .2 to .3 standard deviations in the major outcomes of interest, including adaptation of sustainable land management practices, SLM knowledge, and variables linked to intrahousehold decision-making. Given a relatively sparse literature in this area as described above, identifying a plausible minimum effect size is challenging, but a recent trial conducted in Burkina Faso suggested that the rollout of incentives for the adaptation of sustainable land management practices led to a roughly .38 standard deviation

[8] For each task, a woman will be identified as engaging in the task if she reports she is responsible for this task either solely or jointly. We will primarily analyze women's reports, but may also analyze men's reports of women's engagement in SLM tasks.
[9] A limited, very simple question around household decision-making was included at baseline; we expect to include a more detailed module at endline.
[10] Limited information around climate risk perception was captured at baseline, but we expect more detailed variables to be measured at endline.

increase in adoption of LSM practices (increased adoption of .5 practices, relative to a standard deviation in the control arm of 1.3). Accordingly, it seems plausible to conclude that the trial is adequately powered.

Table 2a: Minimum Detectable Effect (in standard deviations), data from SPIR-1

	Control mean	Control SD	ICC	MDE
Household participated in horticulture in past year	0.067	0.250	0.089	0.261
Female participated in horticulture in past year	0.509	0.505	0.414	0.474
Household applied compost to their crops in past year	0.082	0.275	0.203	0.351
Female had input into most/all input decisions for activities she participated in	0.512	0.500	0.128	0.295

Notes: Data used for the power calculations is from the endline of the SPIR-1 study in Ethiopia (2021). Only control group's data is used.

Table 2b: Minimum Detectable Effect (in standard deviations), data from the HER+ baseline data collection

	Control mean	Control SD	ICC	MDE
Household has any trees	0.703	0.457	0.142	0.306
Household has a home garden	0.492	0.500	0.161	0.320
Household has a compost heap	0.255	0.436	0.111	0.280
Female's total SLM knowledge score (0-8)	3.141	1.669	0.007	0.169

Notes: Data from the HER+ evaluation's baseline survey.

3.3. Empirical specification

We will analyze the primary and secondary outcomes summarized above using an analysis of covariance (ANCOVA) estimation strategy (McKenzie, 2012). We will report two specifications in order to assess first, the pooled effect of any SLM intervention; and second, the effect of the intervention when delivered to women only or couples.

$$Y_{ikd,t=1} = \beta T_{kd} + \gamma Y_{ikd,t=0} + X'_{ikd,t=0}\vartheta + \chi_d + \varepsilon_{ikd},$$

$$Y_{ikd,t=1} = \beta_1 T^1{}_{kd} + \beta_2 T^2{}_{kd} + \gamma Y_{ikd,t=0} + X'_{ikd,t=0}\vartheta + \chi_d + \varepsilon_{ikd},$$

$Y_{ikd,t=1}$ captures the outcome of interest in household *i* residing in kebele (sub-district) *k* and woreda (district) *d* at midline/endline *t,* and $Y_{ikd,t=0}$ corresponds to the same outcome measured at baseline. T_{kd} is a binary variable equal to one if the kebele is randomly assignment to treatment. T^1_{kd} and $T^2_{kd}$are binary variables equal to one if the kebele is randomly assigned to T1 or T2, respectively; in this specification, we also report a p-value corresponding to the hypothesis that $\beta_1 = \beta_2$. The specification includes strata fixed effects (captured in term χ_d) and standard errors clustered at the kebele level. For any outcomes for which baseline data is not available, the same specification will be estimated to capture the simple difference (without baseline controls).

In addition to reporting standard p-values, we will also report p-values corrected for multiple hypothesis testing based on sharpened FDR q-values following Simes (1986); this correction will be implemented across the set of primary outcomes, and across the set of secondary outcomes.

We will also assess heterogeneity in treatment effects with respect to baseline perceived climate risk (as reported by the female respondent), baseline time and risk preference (as reported by the female respondent), and baseline spousal cooperation demonstrated by the wife (as measured by her average level of contribution in both the public and dictator games) and by the husband (as measured by his average level of contribution in the same games). We hypothesize that take-up of SLM practices will be higher in both treatment arms for households reporting a higher perceived level of climatic risk at baseline; and will similarly be higher for households in which the wife reports a higher level of risk aversion and patience at baseline. In addition, we hypothesize that take-up of SLM practices will be differentially higher in the couples' arm vis-à-vis the women's only arm for couples that are more cooperative at baseline.

There will be no imputation for missing data due to item non-response at endline. Missing data on baseline variables will be set to zero and dummied out in the ANCOVA specifications.

4. Empirical patterns at baseline

4.1. Baseline balance

Baseline balance in household characteristics and outcomes of interest across the three treatment arms is reported in Appendix Tables A1a-A3b; we present balance tests both separately for each experimental arm, and pooling T1 and T2 into a single treatment arm. The only variable for which there is slight evidence of imbalance is whether the primary male's primary occupation is crop cultivation, a difference that is marginally significant (p-value = 0.048). The primary and secondary outcomes show no signs of imbalance at baseline.

4.2. Survey and experimental measures of spousal cooperation

We can also use both survey and experimental data collected at baseline to characterize sample households in terms of their level of spousal cooperation, and assess the degree to which these two measures are consistent. On average, the female respondents report that 41% of decisions are made jointly by husband and wife (out of a total of three decisions enumerated), but report that only 9% of tasks are undertaken jointly (out of a total of 20 tasks enumerated). Within those tasks that are reported to be undertaken by a single spouse (either husband or wife), on average women manage eight of those tasks (primarily related to traditional domestic work such as cooking, cleaning, and childcare), while men manage six (primarily related to agricultural production).[11]

[11] The three domains of household decision-making included in the survey are decisions around health care for the female respondent, decisions around major household purchases, and decisions around visits by the female respondent to friends / relatives, a simple module that is drawn from the Demographic and Health Survey. The 20 domains of household task allocation included in the survey are preparing land, sowing/seeding, weeding, irrigation, harvesting food, selling produce at the market, planting trees, collecting materials for compost, maintaining and applying compost, care for large livestock, care for small livestock, care for poultry, selling livestock products at market, selling livestock at market, fetching water, obtaining fuel, cooking food, cleaning, feeding young children, and watching young children at home.

To assess the concordance between survey and experimental measures of spousal cooperation, we estimate the following regression.

(3) $$Survey_{hk} = \beta\ ContSpouse_{ihk} + Countstranger_{ihk} + \varepsilon_{ihk}$$

$Survey_{hk}$ corresponds to a variable capturing spousal cooperation within household h in kebele k reported in the survey (always by the female respondent), either the percentage of decisions made jointly or the percentage of tasks conducted jointly. The explanatory variables are the contribution levels in the public goods or dictator game, reported by the male or the female spouse when playing with the other spouse; the specification also controls for the specified contribution in the same game by the same individual, playing vis-à-vis a stranger of the opposite gender. (We follow Getahun et al. 2020 in using this specification to assess spousal cooperation.) We estimate equation (3) separately for experimental data for the female and male samples, respectively, and then for the pooled sample; in all specifications, standard errors are clustered at the kebele level.

Table 3 reports the results; note that each cell corresponds to a separate regression. It is evident that there is a significant and positive association between the percentage of decisions made jointly and the contributions of both men and women when playing vis-a-vis their spouses in both the dictator and the public goods game. However, these associations are largely not evident for the percentage of joint tasks within a household, other than the association with women's contributions in the dictator game and to some extent women's contributions within the public goods game (though the latter coefficient is not statistically significant).

Table 3: Associations between survey and experimental measures of spousal cooperation

	Share of endowment contributed during a game with spouse					
	Dictator game (men)	Dictator game (women)	Dictator game (pooled)	Public goods game (men)	Public goods game (women)	Public goods game (pooled)
Percentage of joint decisions in household	0.035**	0.025**	0.030***	0.019	0.030**	0.025***
	(0.014)	(0.012)	(0.010)	(0.014)	(0.013)	(0.010)
Percentage of joint tasks in household	0.003	0.105***	0.047	-0.012	0.024	0.006
	(0.046)	(0.040)	(0.032)	(0.045)	(0.042)	(0.031)

4.3. Household preferences, demographic characteristics, and adoption of SLM practices

We also use baseline data from both the survey and the spousal cooperation games to assess the association between household preferences (time and risk preference, spousal cooperation, and perception of climate risks) and baseline observed adoption of sustainable land management practices, prior to the introduction of the training interventions. The latter is captured by binary variables for whether the household has any trees, any trees less than three years old, any compost heap, and any household garden, all recorded via direct observation by the enumerator, with verification by the

respondents.[12] Given evidence from our formative qualitative work that time availability may be a meaningful constraint for the adoption of SLM practices, we also assess the association between demographic characteristics related to the availability of adult labor supply and the same adoption variables. These associations should not be considered causal, however, given the potential for omitted variable bias.

More specifically, we estimate the following regression, where the dependent variable captures adoption of a SLM practice for household h in kebele k, and X_{hk} corresponds to a covariate of interest measured for the same household. For variables measured in the spousal cooperation game, we again control for the corresponding contribution by the same individual in the same game vis-à-vis a stranger of the opposite gender.

(4) $$Adoption_{hl} = \beta X_{hk} + \varepsilon_{hk}$$

The results are reported in Tables 4a and 4b. In general, in Table 4a there is little evidence that households that are more cooperative are more likely to have adopted SLM practices at baseline; if anything, the relationship is generally negative, though not always statistically significant. There is also some weak evidence that households that are more risk averse are more likely to have adopted composting and household gardening, though time preference does not appear to be predictive of take-up. However, binary variables equal to one if respondents report that they noticed changes in climate or are concerned about changes in climate are generally strongly predictive of reported household adoption of trees and composting.

There is also some evidence of associations between adoption and household demographic composition, generally in the predicted direction: households characterized by more members under five years of age are less likely to report adoption of SLM practices (possibly reflecting the time demands associated with caregiving for infants and young children), while households characterized by more members over 12 years of age are significantly more likely to report such adoption.

To sum up, baseline associations suggest that spousal cooperation and time and risk preferences do not seem to be meaningful predictors of adoption of SLM practices ex ante; however, both perceptions of climate risk and household demographic characteristics are significantly associated with adoption variables. The prespecified analysis of heterogeneous effects in the context of the experiment (described above) will explore further whether these household characteristics are predictive of take-up (or differential take-up in the couples' training arm) in the context of a randomized intervention encouraging SLM adoption.

[12] The survey had follow-up questions about how many of the trees are fruit trees, and how many of them were planted in the last 3 years, in which case enumerators also consulted with the respondent to verify their observations.

Table 4a: Associations between baseline household characteristics and adoption of SLM practices

	Share of endowment contributed during a game with spouse					
	Dictator game (men)	Dictator game (women)	Dictator game (pooled)	Public goods game (men)	Public goods game (women)	Public goods game (pooled)
Household has any trees	-0.032**	-0.013	-0.022**	-0.030**	-0.014	-0.021**
	(0.014)	(0.012)	(0.009)	(0.013)	(0.012)	(0.009)
Household has trees planted in last 3 years	-0.022*	0.001	-0.010	-0.011	-0.001	-0.006
	(0.013)	(0.011)	(0.009)	(0.013)	(0.011)	(0.009)
Household has a garden	-0.016	-0.012	-0.013	-0.023*	-0.035***	-0.029***
	(0.012)	(0.011)	(0.008)	(0.012)	(0.011)	(0.008)
Household has a compost heap	0.004	-0.002	0.003	-0.015	-0.007	-0.012
	(0.014)	(0.012)	(0.010)	(0.014)	(0.013)	(0.009)

Notes: Estimates from the HER+ SLM baseline survey. Standard errors are in parentheses and clustered at the household level. Asterisks indicate significance at the 10, 5 and 1 percent level and are calculated with respect to the standard errors.

Table 4b: Associations between baseline household characteristics and adoption of SLM practices, cont.

	Patience (women)	Risk aversion (women)	Respondent has noticed changes in climate over her lifetime	Respondent is concerned about long-term changes in climate	Number of household members aged under 5 years	Number of household members aged over 12 years
Household has any trees	0.009	0.027	0.059***	-0.013	-0.103**	0.758***
	(0.026)	(0.025)	(0.022)	(0.015)	(0.043)	(0.062)
Household has trees planted in last 3 years	0.004	0.032	0.079***	0.035**	-0.004	0.479***
	(0.024)	(0.024)	(0.019)	(0.014)	(0.043)	(0.069)
Household has a garden	0.024	0.039*	0.017	-0.026*	0.061	0.387***
	(0.024)	(0.023)	(0.019)	(0.014)	(0.041)	(0.065)
Household has a compost heap	-0.023	0.050*	0.085***	0.064***	-0.036	0.081
	(0.027)	(0.026)	(0.021)	(0.014)	(0.045)	(0.075)

Notes: Estimates from the HER+ SLM baseline survey. Standard errors are in parentheses and clustered at the household level. Asterisks indicate significance at the 10, 5 and 1 percent level and are calculated with respect to the standard errors.

Table A1a: Balance in baseline household characteristics

	Mean and standard deviation			p-value		
	T1: Women only	T2: Women & men	T3: Control	T1 vs T3	T2 vs T3	T1 vs T2
Household size	5.608	5.452	5.617	0.969	0.476	0.481
	(1.863)	(1.851)	(1.985)			
Number of children under 5 years of age	0.889	0.922	0.900	0.865	0.753	0.612
	(0.788)	(0.810)	(0.775)			
Distance to the market that household mostly visits (minutes)	73.659	73.253	73.362	0.973	0.990	0.967
	(53.601)	(49.004)	(46.242)			
Household head is female	0.009	0.003	0.003	0.185	0.895	0.231
	(0.095)	(0.059)	(0.055)			
Primary female's age	34.873	34.302	34.503	0.705	0.841	0.565
	(9.566)	(9.358)	(9.834)			
Primary female is married (monogamously)	0.997	0.993	0.989	0.147	0.486	0.385
	(0.055)	(0.083)	(0.103)			
Primary female has no education	0.711	0.645	0.777	0.537	0.226	0.185
	(0.454)	(0.479)	(2.585)			
Primary female completed primary education (6 grades)	0.118	0.141	0.214	0.348	0.484	0.551
	(0.323)	(0.349)	(2.584)			
Primary female's primary occupation is crop cultivation	0.582	0.522	0.538	0.314	0.743	0.233
	(0.494)	(0.500)	(0.499)			
Primary male's age	42.938	42.853	42.503	0.702	0.763	0.942
	(11.386)	(11.583)	(11.859)			
Primary male is married (monogamously)	0.973	0.984	0.962	0.542	0.159	0.278
	(0.163)	(0.124)	(0.191)			
Primary male has no education	0.571	0.581	0.617	0.251	0.431	0.833
	(0.495)	(0.494)	(0.487)			
Primary male completed primary education (6 grades)	0.198	0.190	0.158	0.210	0.375	0.833
	(0.399)	(0.392)	(0.365)			
Primary male's primary occupation is crop cultivation	0.953	0.921	0.979	0.128	0.048**	0.318
	(0.212)	(0.270)	(0.144)			

Notes: Summary statistics from the HER+ SLM baseline survey. Standard deviations are in parentheses. P-value is from the test of difference of means between the treatment arms. Standard errors are clustered at the kebele level.

Table A1b: Balance in baseline household characteristics, pooled treatment arms

	Mean and standard deviation		p-value
	Pooled treatment	Control	T vs C
Household size	5.535	5.617	0.689
	(1.858)	(1.985)	
Number of children under 5 years of age	0.905	0.900	0.934
	(0.798)	(0.775)	
Distance to the market that household mostly visits (minutes)	73.469	73.362	0.988
	(51.482)	(46.242)	
Household head is female	0.006	0.003	0.288
	(0.080)	(0.055)	
Primary female's age	34.606	34.503	0.904
	(9.470)	(9.834)	
Primary female is married (monogamously)	0.995	0.989	0.225
	(0.069)	(0.103)	
Primary female has no education	0.680	0.777	0.355
	(0.467)	(2.585)	
Primary female completed primary education (6 grades)	0.129	0.214	0.398
	(0.335)	(2.584)	
Primary female's primary occupation is crop cultivation	0.554	0.538	0.670
	(0.497)	(0.499)	
Primary male's age	42.898	42.503	0.689
	(11.474)	(11.859)	
Primary male is married (monogamously)	0.978	0.962	0.306
	(0.146)	(0.191)	
Primary male has no education	0.576	0.617	0.246
	(0.494)	(0.487)	
Primary male completed primary education (6 grades)	0.194	0.158	0.175
	(0.396)	(0.365)	
Primary male's primary occupation is crop cultivation	0.938	0.979**	0.017
	(0.241)	(0.144)	

Notes: Summary statistics from the HER+ SLM baseline survey. Standard deviations are in parentheses. P-value is from the test of difference of means between the treatment arms. Standard errors are clustered at the kebele level.

Table A2a: Balance in asset ownership at baseline

	Mean and standard deviation			p-value		
	T1: Women only	T2: Women & men	T3: Control	T1 vs T3	T2 vs T3	T1 vs T2
Standardized Livestock Units	0.595 (0.576)	0.534 (0.565)	0.542 (0.547)	0.342	0.883	0.286
Household Productive Asset Index	-0.130 (1.613)	0.099 (1.553)	0.043 (1.651)	0.515	0.826	0.387
Livestock Asset Index	0.025 (1.184)	-0.073 (1.167)	0.039 (1.182)	0.900	0.352	0.412
Household Total Asset Index (productive assets + livestock)	-0.117 (1.751)	0.070 (1.643)	0.056 (1.723)	0.527	0.959	0.495
Value of all productive assets (in Birr)	1,318.106 (911.064)	1,379.595 (973.766)	1,350.845 (961.003)	0.706	0.741	0.430
Value of all livestock (in Birr)	17,690.091 (20,283.610)	16,886.138 (20,529.154)	17,480.485 (21,976.585)	0.927	0.799	0.694
Value of productive assets and livestock combined (in Birr)	19,008.197 (20,598.330)	18,265.733 (20,882.363)	18,831.330 (22,298.057)	0.940	0.812	0.722

Notes: Summary statistics from the HER+ SLM baseline survey. Standard deviations are in parentheses. P-value is from the test of difference of means between the treatment arms. Standard errors are clustered at the kebele level.

Table A2b: Balance in asset ownership at baseline, pooled treatment arms

	Mean and standard deviation		p-value
	Pooled treatment	Control	T vs C
Standardized Livestock Units	0.566 (0.571)	0.542 (0.547)	0.618
Household Productive Asset Index	-0.023 (1.589)	0.043 (1.651)	0.770
Livestock Asset Index	-0.021 (1.177)	0.039 (1.182)	0.555
Household Total Asset Index (productive assets + livestock)	-0.030	0.056	0.711

	(1.703)	(1.723)	
Value of all productive assets (in 1,000 Birr)	1.347	1.351	0.959
	(0.941)	(0.961)	
Value of all livestock (in 1,000 Birr)	17.314	17.480	0.936
	(20.395)	(21.977)	
Value of productive assets and livestock combined (in 1,000 Birr)	18.661	18.831	0.936
	(20.727)	(22.298)	

Notes: Summary statistics from the HER+ SLM baseline survey. Standard deviations are in parentheses. P-value is from the test of difference of means between the treatment arms. Standard errors are clustered at the kebele level.

Table A3a: Balance in observed SLM practice use at baseline

	Mean and standard deviation			p-value		
	T1: Women only	T2: Women & men	T3: Control	T1 vs T3	T2 vs T3	T1 vs T2
Household has trees	0.705	0.709	0.703	0.977	0.905	0.934
	(0.457)	(0.455)	(0.457)			
Total number of trees that household has	35.994	26.997	35.409	0.961	0.436	0.428
	(100.794)	(65.831)	(109.720)			
Total number of trees that were planted in last 3 years	6.598	5.062	5.503	0.564	0.805	0.445
	(27.685)	(20.892)	(21.361)			
Total number of fruit trees that household has	1.948	1.407	1.306	0.265	0.817	0.369
	(7.893)	(4.553)	(4.898)			
Total number of fruit trees that were planted in last 3 years	1.080	0.648	0.626	0.280	0.909	0.317
	(6.405)	(2.241)	(2.080)			
Household has a home garden	0.495	0.457	0.492	0.956	0.514	0.528
	(0.500)	(0.499)	(0.500)			
Area of the home garden (sq meters)	66.907	76.220	81.290	0.736	0.919	0.844
	(188.877)	(218.977)	(207.473)			
Household has a manure pile (raw)	0.327	0.371	0.326	0.963	0.236	0.292
	(0.470)	(0.483)	(0.469)			
Household has a compost pile	0.217	0.262	0.255	0.355	0.867	0.287
	(0.412)	(0.440)	(0.436)			

Notes: Summary statistics from the HER+ SLM baseline survey. Standard deviations are in parentheses. P-value is from the test of difference of means between the treatment arms. Standard errors are clustered at the kebele level.

Table A3b: Balance in observed SLM practice use at baseline, pooled treatment arms

	Mean and standard deviation		p-value
	Pooled treatment	Control	T vs C
Household has trees	0.706 (0.456)	0.703 (0.457)	0.936
Total number of trees that household has	31.785 (86.308)	35.409 (109.720)	0.716
Total number of trees that were planted in last 3 years	5.880 (24.743)	5.503 (21.361)	0.808
Total number of fruit trees that household has	1.695 (6.550)	1.306 (4.898)	0.352
Total number of fruit trees that were planted in last 3 years	0.878 (4.920)	0.626 (2.080)	0.326
Household has a home garden	0.477 (0.500)	0.492 (0.500)	0.742
Area of the home garden (sq meters)	71.075 (202.780)	81.290 (207.473)	0.795
Household has a manure pile (raw)	0.348 (0.476)	0.326 (0.469)	0.442
Household has a compost pile	0.238 (0.426)	0.255 (0.436)	0.655

Notes: Summary statistics from the HER+ SLM baseline survey. Standard deviations are in parentheses. P-value is from the test of difference of means between the treatment arms. Standard errors are clustered at the kebele level.

Table A4a: Balance in allocation of household tasks at baseline

	Mean and standard deviation			p-value		
	T1: Women only	T2: Women & men	T3: Control	T1 vs T3	T2 vs T3	T1 vs T2
Preparing land is done by the female, or jointly by female and male	0.020 (0.139)	0.026 (0.159)	0.020 (0.139)	1.000	0.562	0.578
Sowing/seeding is done by the female, or jointly by female and male	0.038 (0.191)	0.033 (0.178)	0.024 (0.154)	0.304	0.494	0.684

Weeding is done by the female, or jointly by female and male	0.458 (0.499)	0.488 (0.500)	0.482 (0.500)	0.746	0.934	0.690
Harvesting food is done by the female, or jointly by female and male	0.233 (0.423)	0.240 (0.427)	0.206 (0.405)	0.577	0.499	0.906
Taking the produce to the market is done by the female, or jointly by female and male	0.605 (0.489)	0.598 (0.491)	0.602 (0.490)	0.950	0.941	0.872
Planting trees is done by the female, or jointly by female and male	0.121 (0.327)	0.110 (0.314)	0.100 (0.300)	0.317	0.651	0.648
Collecting materials for compost is done by the female, or jointly by female and male	0.305 (0.461)	0.278 (0.448)	0.261 (0.439)	0.302	0.699	0.553
Maintaining and applying compost is done by the female, or jointly by female and male	0.211 (0.408)	0.224 (0.417)	0.185 (0.388)	0.462	0.303	0.733

Notes: Summary statistics from the HER+ SLM baseline survey. Standard deviations are in parentheses. P-value is from the test of difference of means between the treatment arms. Standard errors are clustered at the kebele level.

Table A4b: Balance in allocation of household tasks at baseline, pooled treatment arms

	Mean and standard deviation		p-value
	Pooled treatment	Control	T vs C
Preparing land is done by the female, or jointly by female and male	0.023 (0.149)	0.020 (0.139)	0.731
Sowing/seeding is done by the female, or jointly by female and male	0.036 (0.185)	0.024 (0.154)	0.313
Weeding is done by the female, or jointly by female and male	0.473 (0.499)	0.482 (0.500)	0.884
Harvesting food is done by the female, or jointly by female and male	0.237 (0.425)	0.207 (0.405)	0.467
Taking the produce to the market is done by the female, or jointly by female and	0.675 (0.469)	0.665 (0.472)	0.808
Planting trees is done by the female, or jointly by female and male	0.139 (0.347)	0.118 (0.323)	0.332
Collecting materials for compost is done by the female, or jointly by female and male	0.445 (0.497)	0.426 (0.495)	0.743
Maintaining and applying compost is done by the female, or jointly by female and male	0.336	0.303	0.492

	(0.473)	(0.460)	

Notes: Summary statistics from the HER+ SLM baseline survey. Standard deviations are in parentheses. P-value is from the test of difference of means between the treatment arms. Standard errors are clustered at the kebele level.

5. References

Adjognon, G. S., Huy, T. N., Guthoff, J., & van Soest, D. (2022). Incentivizing social learning for the diffusion of climate-smart agricultural techniques. World Bank Policy Research Working Paper.

Ahmed, S. & E. Kiester. (2021). Do gender differences lead to unequal access to climate adaptation strategies in an agrarian context? Perceptions from coastal Bangladesh. Local Environment 26(5):650-665.

Asfaw, S., McCarthy, N., Lipper, L., Arslan, A., Cattaneo, A., & Kachulu, M. (2014). Climate variability, adaptation strategies and food security in Malawi (No. 288980). Food and Agriculture Organization of the United Nations, Agricultural Development Economics Division (ESA).

Asfaw, S., & Maggio, G. (2018). Gender, weather shocks and welfare: Evidence from Malawi. The Journal of Development Studies, 54(2), 271-291.

Bezabih, M., & Sarr, M. (2012). Risk preferences and environmental uncertainty: Implications for crop diversification decisions in Ethiopia. Environmental and Resource Economics, 53, 483-505.

Branca, G., Lipper, L., McCarthy, N., & Jolejole, M. C. (2013). Food security, climate change, and sustainable land management. A review. Agronomy for sustainable development, 33, 635-650.

Cholo, T. C., Peerlings, J., & Fleskens, L. (2020). Gendered climate change adaptation practices in fragmented farm fields of Gamo Highlands, Ethiopia. Climate and development, 12(4), 323-331.

Constenla-Villoslada, S., Liu, Y., Wen, J., Sun, Y., & Chonabayashi, S. (2022). Large-scale land restoration improved drought resilience in Ethiopia's degraded watersheds. Nature Sustainability, 5(6), 488-497.

Ding, Y., Balcombe, K. and Robinson, E. (2021). Time discounting and implications for Chinese farmer responses to an upward trend in precipitation. J Agric Econ, 72: 916-930.

FAO (2019). Africa Regional Synthesis for The State of the World's Biodiversity for Food and Agriculture. Tech. rep., Food and Agriculture Organization of the United Nations. https://www.fao.org/3/ca4643en/ca4643en.pdf

Feder, G., Just, R. E., & Zilberman, D. (1985). Adoption of agricultural innovations in developing countries: A survey. Economic development and cultural change, 33(2), 255-298.

Fikreyesus, D.; Gizaw, S.; Mayers, J. and Barrett, S. (2022). Mass Tree Planting: Prospects for a Green Legacy in Ethiopia, Country Report, London: IIED. https://opendocs.ids.ac.uk/opendocs/handle/20.500.12413/17524

Getahun, T., Bjorvatn, K., and S.K. Halvorsen (2020). Conflict or cooperation? Experimental evidence on intra-household allocations in Ethiopia. Journal of Behavioral and Experimental Economics 85, 101508.

Ginbo, T. and Hansson, H. 2023. Intra-household risk perceptions and climate change adaptation in sub-Saharan Africa. European Review of Agricultural Economics. Vol. 50 (3). Haregeweyn, N., Tsunekawa, A., Tsubo, M., Fenta, A. A., Ebabu, K., Vanmaercke, M., ... & Poesen, J. (2023). Progress and challenges in sustainable land management initiatives: A global review. Science of The Total Environment, 858, 160027.

Hirvonen, K., Machado, E. A., Simons, A. M., & Taraz, V. (2022). More than a safety net: Ethiopia's flagship public works program increases tree cover. Global Environmental Change, 75, 102549.

Huyer, S., T. Gumucio, K. Tavenner, M. Acosta, N. Chanana, A. Khatri-Chhetri, C. Mungai, et al. (2021). "From Vulnerability to Agency in Climate Adaptation and Mitigation." In Advancing Gender Equality through Agriculture and Environmental Research: Past, Present, and Future, 261–94. Washington, DC: International Food Policy Research Institute.

Jin, J., Y. Gao, X. Wang, and P.K. Nam. (2025). Farmers' risk preferences and their climate change adaptation strategies in the Yongqiao District, China. Land Use Policy 47, 365-372.

Jost, C., Kyazze, F., Naab, J., Neelormi, S., Kinyangi, J., Zougmore, R., ... & Kristjanson, P. (2016). Understanding gender dimensions of agriculture and climate change in smallholder farming communities. Climate and Development, 8(2), 133-144.

Ketema, T., Bedi, T., Buehren, N., & Goldstein, M. (2023). Shifting Spousal Decision-Making Patterns: Whom You Target in an Agricultural Intervention Matters. The Impact of the Farmer's Innovation Fund in Ethiopia.

Kondylis, F., Mueller, V., Sheriff, G., & Zhu, S. (2016). Do female instructors reduce gender bias in diffusion of sustainable land management techniques? Experimental evidence from Mozambique. World Development, 78, 436-449.

Lambrecht, I., Vanlauwe, B., & Maertens, M. (2016). Agricultural extension in eastern Democratic Republic of Congo: Does gender matter? European Review of Agricultural Economics, 43(5), 841–874.

Lecoutere, E., Spielman, D. J., & Van Campenhout, B. (2023). Empowering women through targeting information or role models: Evidence from an experiment in agricultural extension in Uganda. World Development, 167, 106240.

Ngigi, M.W., Mueller, U. and Birner, R. (2017). Gender Differences in Climate Change Adaptation Strategies and Participation in Group-based Approaches: An Intra-household Analysis from Rural Kenya. Ecological Economics, 138:99-108.

Quisumbing, A. R., and Kumar, N. (2014). Land Rights Knowledge and Conservation in Rural Ethiopia: Mind the Gender Gap." IFPRI Discussion Paper 1386. Washington, DC: IFPRI Discussion Paper.

Perez, C., Jones, E. M., Kristjanson, P., Cramer, L., Thornton, P. K., Förch, W. and C. Barahona. (2015). How Resilient Are Farming Households and Communities to a Changing Climate in Africa? A Gender-Based Perspective. Global Environmental Change 34: 95–107.

Pretty, J., Benton, T. G., Bharucha, Z. P., Dicks, L. V., Flora, C. B., Godfray, H. C. J., Goulson, D., Hartley, S., Lampkin, N., Morris, C., Pierzynski, G., Prasad, P. V. V., Reganold, J., Rockström, J., Smith, P., Thorne, P. and Wratten, S. (2018). Global assessment of agricultural system redesign for sustainable intensification. Nature Sustainability, pp. 441–446.

Shiferaw, B., & Holden, S. T. (1998). Resource degradation and adoption of land conservation technologies in the Ethiopian highlands: A case study in Andit Tid, North Shewa. Agricultural Economics, 18(3), 233–248.

Shiferaw, B. A., Okello, J., & Reddy, R. V. (2009). Adoption and adaptation of natural resource management innovations in smallholder agriculture: reflections on key lessons and best practices. Environment, development and sustainability, 11, 601-619.

Tefera, M., Gilligan, D. O., Leight, J. and Tambet, J. (2023). Women's Participation in Sustainable Land Management Practices of the PSNP 5 Public Works Program in Amhara and Oromiya Regions of Ethiopia. Unpublished manuscript.

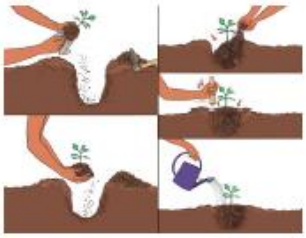
Teklewold, H., Kassie, M. and Shiferaw, B. (2013). Adoption of multiple sustainable agricultural practices in rural Ethiopia. Journal of Agricultural Economics, 64 (3), 597–623.

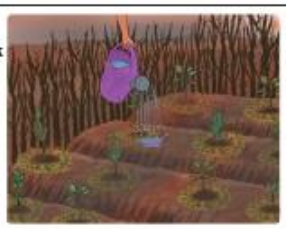
Teklewold, H., & Köhlin, G. (2011). Risk preferences as determinants of soil conservation decisions in Ethiopia. Journal of Soil and Water Csonservation, 66(2), 87-96.

Wossen, T., Berger, T., & Di Falco, S. (2015). Social capital, risk preference and adoption of improved farm land management practices in Ethiopia. Agricultural Economics, 46(1), 81-97.

Zilberman, D., Zhao, J., & Heiman, A. (2012). Adoption versus adaptation, with emphasis on climate change. Annu. Rev. Resour. Econ., 4(1), 27-53.

Appendix 1: Planning card for the joint planning exercise

	Activity እንቅስቃሴ	Task ተግባር	Who has primary responsibility? ዋነኛ ኃላፊነት ያለበት ማነው? ባል Husband	 ሚስት Wife
Estab-lishment አዘገጃጀት	Home garden የጓሮ አትክልት ቦታ	Planning the vegetable layout and visiting an agrodealer for seeds የአትክልቱን አቀማመጥ ማቀድና ዘሮችን ለማግኘት ወደ ዘር አቅራቢ መሄድ፡፡ 		
		Preparing the raised or sunken garden bed/soil and doing the first planting የአትክልት ቦታውን ከፍ ወይም ዝቅ ያለ መደብ ማዘጋጀትና የመጀመሪያውን ተከላ ማካሄድ 		
	Compost ፍጋፍግ/ ብስባሽ	Finding a location for the compost heap or pit, collecting and setting materials for the first layers of the compost heap or pit ለፍጋፍግ/ለብስባሽ የመቆለያ ወይም የማጠራቀሚያ ጉድጓድ ቦታ መፈለግ፣ ለቁልሉ ወይም ለጉድጓዱ የመጀመሪያ ርብራቦች የሚሆኑ ቁሶችን መሰብሰብና መረብረብ 		
	Trees ዛፎች	Laying out the tree system and digging the planting pits ዛፎች የሚተከልበትን ቦታ መቀየስ የአትክልት መትከያ ጉድጓዶችን መቆፈር 		
		Planting the trees following the trainings የአትክልት መትከያ ጉድጓዶችን መቆፈር ዛፎችን መመሪያዎችን ተከትሎ መትከል 		

	እንቅስቃሴ	ተግባር	ዋኛ ኃላፊነት ያለበት ማነው? ባል	ሚስት
Maintenance ጥገና	Compost ፍጋፍግ/ብስባሽ	Collecting green material, brown material, manure አረንጓዴ ቁስ፣ የገረጣ ቁስና ፍግ መስብሰብ 		
		የቁልሉን ወይም የጉድጓዱን ፍጋፍግ/ብስባሽ መደራረብ፣ አዘውትሮ ማገላበጥና ውሃ መጨመር Layering the compost heap or pit, regularly turning it up and adding water 		
	Home garden የጓሮ አትክልት ቦታ	Watering the vegetables አትክልትን ውሃ ማጠጣት 		
		Weeding the vegetables አትክልትን ማረም 		
		Applying compost to vegetables, or mix of topsoil and manure if compost is not ready ለአትክልት ብስባሽ ማዳበሪያ ማድረግ 		
		Harvesting the vegetables, continuously planting new ones አትክልትን መሰብሰብና አዲስ አትክልትን ያለማቋረጥ መትከል 		
		Selling vegetables አትክልት መሸጥ 		
	Trees ዛሮች	Protecting the trees from livestock ዛፎችን አጥር በማጠር ከእንስሳት መጠበቅ ዛፎችን አዘውትሮ ውሃ ማጠጣት Regularly watering the trees 		

Note: The English translations are added for the purposes of the pre-analysis plan.

Appendix 2: Protocol for the spousal cooperation game

Setting: All 20 couples surveyed in a kebele are invited to an experimental session to be conducted at a central location at the end of the survey period. Both men and women are informed they can earn a minimum of 100 birr and an average of 300 birr for the session (per individual). They are also informed they will be compensated separately (both spouses), but they can only be compensated if both members of the couple are present; an individual who arrives at the session alone cannot participate or be compensated. Session times will be available at 10 AM and 2 PM, and the respondents will be assigned a time by the survey team; but if they disagree or are not available, they can attend at the other time.

Note: All participants receive a 100 birr show-up fee PLUS their earnings from one of the four games, selected randomly (public goods game with spouse or stranger; dictator game with spouse or stranger. For the games with strangers, we will elicit decisions about choices vis-à-vis a stranger of the same gender and opposite gender, but all participants will be matched to another (stranger) participant of the opposite gender and paid on that basis. Participants will receive all earnings in cash at the conclusion of the session, and sign a receipt.

List of required materials:

- Play money (50 birr, 10 birr and 20 birr notes) = 40X+10X
- White couples' ID cards with numbers printed
- Yellow lottery cards with the types of game and number printed on it (P-SP, P-STR, D-SP, D-STR)
- Tokens with printed numbers
- Real coins (head and tails for illustrating 50%, 50% probability of gaining or losing)
- Envelope (blue and green)
- Envelope (blue and green)
- Basket
- Non-transparent bag/urn
- Venue for the games
- Actual cash

Instruction for enumerators: respondents' arrival

1. Opposite sex enumerators will work in pairs. We will have 2 or 3 pairs of enumerators at a session. Each pair of enumerators will then be responsible for half or one third of the couples that attend the session.
2. Please ensure that couples are told to arrive on time. Provide a 15–30-minute wait time at maximum for most of the participants to arrive to start the session. For the morning session participants who are arriving more than 30 minutes late, please encourage them to attend the afternoon session. For the afternoon session participants who are arriving more than 30 minutes late, please tell them that they are too late to participate in the couples' game and ask them to leave, after providing water (if they wish) and a 25 birr late show up fee.
3. In every session, when couples arrive at the location, please check their full name from the baseline survey participants list in the kebeles to verify that only baseline respondents participate in the couple's game. [Note: it is important to remind participants to bring their IDs, if possible.]
4. Call participants in the order of the list provided to each enumerator and provide the play ID cards printed with numbers; these will serve as a couples' ID. The ID will be numbered as 1, 2, 3 . . .N, where N is the total number of couples in a session. Each couple (husband and wife) will receive an identical couples' ID. **The participants must retain the white couples' ID with them until the end of the game.**
5. Then advise the couple to take a seat. Please seat men on one side of the line and women on the other side of the line, ensuring some distance (1 to 2 meter) between spouses from the same household.

Enumerator introductory script: (Note that any italicized text is to be read aloud.)

Thank you for attending the experimental session today. First I will explain the activities that we will be doing, and then you will have the opportunity to make some choices and I will record your choices. These choices will be related to how much you are paid. Everyone will receive 100 birr as a thanks for their time in joining us today. Depending on your choices in the game, you can earn more. Your earnings will be paid to you at the end of our session, in cash, in a private envelope.

All your choices today are private. You do not need to share them with others in the session or with your spouse, and I will explain how you will use your basket and other materials to maintain your privacy. I will be here to answer your questions and to record your decisions. The choices you make are entirely up to you.

You will participate in four different activities today. At the end of the session, we will choose one of those activities by lottery, and you will be paid based on your choice in that activity. Any of your choices could determine your final payment, so I encourage you to make your choices carefully. On average, you may earn around 200 birr more in the activities, in addition to the 100 birr you will receive for attending. The amount you earn may be less or more.

Before we start our games, we are going to do a brief lottery activity. This will not be part of the game, it is just for us to record.

Enumerators Instruction for Randomization

1. To randomly assign each individual in to one of the four games for determining their game pay off, prepare four different types of yellow lottery cards labeled as 1 =P-SP, 2=P-STR, 3=D-SP, 4=D-STR.

   To determine the number of each type of the lottery card to be put inside the bag/urn, count how many participants are attending the session and divide by 4. However, if the number of participants is not a multiple of 4, find the closest multiple of 4 that is ***higher*** than the number of couples attending the session and then divide by 4.

   Each participant will then pick the numbered/labeled yellow lottery card out of the bag. **The participants must keep the lottery card with them until the end of the game.**

2. To randomly pair each woman with another man (stranger), now put N number of numerical tokens in the bag. Each woman will pull out of the bag a numbered **token**; if she pulls her own number, return that number to the bag, and allow her to pull again. After she pulls a number that is different from her own**,** move onto the next woman. **She must keep the token with her until the end of the game.** The men do not need to participate in this exercise. When you are finished, each woman will have been matched to a man who is not her spouse. These are the pairings that can be used later in calculating payments. The male enumerators need to record the matches for each male participant on a piece of paper to transfer it into CAPI later.

3. Before starting to facilitate the game, please complete the control and randomization section in the CAPI and partially save the data by the respondent's full name.

Section 0: Control and Randomization section

R1: Address 1) Woreda _____ 2) Kebele_____

R2. Full name of the participant _____

R3. Gender of the respondent _____ 1=Female 2=Male

R4. Full Name of the Spouse _____

R5. Couples ID (refer the number printed in the white ID card):_____

R6. To which game the participant is randomized (refer to the number printed in the yellow card):

_____

1 = Public good –Stranger 2 = Public good –Spouse 3 = Dictator-Stranger 4 = Dictator -Spouse

R7. Record the match number for the opposite sex stranger game (refer to the number printed on the token for female participants, and your notes for male participants): _____

Enumerator script: Public goods games

In this activity, not only your choice, but also the choice of another participant will determine your earnings. You will be paired with another participant, but you will not know who this participant is. Both of you will receive 200 birr and you will both allocate the money between ***yourself (your private envelope)*** *and a* ***common envelope****. Whatever is placed in the* ***common envelope*** *by you and the other person is increased by 50% by the experimenters, and then shared equally between the two of you.*

Your half of the higher amount (increased by 50%) will be placed in your common envelope which you will receive at the end. The money you put in the private envelope is not increased, but goes directly to you at the end of the game.

Right now, we are giving you pretend paper bills that add up to 200 birr (the large ones are denominated 50 birr, the medium ones 10 birr, and the smallest ones 5 birr) in a basket. Inside the basket are two envelopes, the blue one and the green one. The blue one is private for you. The green one is common and shared with your partner. You can decide how to allocate your bills across the envelopes. Later, we will pay you based on this decision with real birr. You can keep your envelopes inside your basket when making the decisions, then no one else can observe what you have chosen to do.

Let us explain with three examples:

Example 1. *Let's say that you put your 200 birr in the common envelope, leaving zero for your private envelope, and the other person puts 60 Birr in the common envelope, leaving 140 Birr in his or her private envelope. There will then be 200 + 60 = 260 birr in the common envelope to which we will add 50 percent (equal to 130 birr). The common envelope will now contain 260 + 130 = 390 Birr, which will then be divided equally between you and the other person, so that each of you will get 390 / 2 or 195 birr. (We will use numbers that are divisible by 5 only.)*

Your earnings: 195 birr = 0 birr in your private envelope + 195 birr from the common envelope.

The other person's earning: 335 birr = 140 birr in partner's private envelope + 195 birr from the common envelope.

Example 2. *Let's say that you and the other person both put 100 birr in the common envelope, retaining 100 birr for yourself. The common envelope has 200 birr, to which we will add 50 percent (100 birr) and it will then contain 300 birr. This will be divided equally between the two of you, so that each of you will receive 150 birr back.*

Both of you will earn 250 birr in total: 100 birr from your private envelope, and 150 birr returned from the common envelope.

Example 3.

Let's say you put 100 birr in the common envelope, while your partner puts all 200 birr in the common envelope.

I would like to ask you some questions.

1) *How many birr are in the common envelope at first? [300]*

2) *After we, the enumerators, add 50%, how many birr will be in the common envelope? [450]*

3) *How much will be returned to each person from the common envelope? [225]*

4) *How much will you earn, and how much will your partner earn? [You will earn 100 + 225 = 325, while your partner will earn 0 + 225 = 225.]*

Enumerator instructions: Record the participants' answers to question number 3 above before you explain the correct answer.

Eg3.How much will be returned to each person from the common envelope? _____

If the respondent(s) reported a wrong answer, ensure that every participant has the opportunity to ask follow-up questions and understands the responses before continuing. After explaining one more time record whether each participant's level of comprehension is high, medium or low.

Eg3.1: How do you evaluate participant's level of comprehension?
1 = low 2 = medium 3 = high

Enumerator script*: Now, I will ask you to make some decisions about how you will allocate your birr across the private and common envelopes. You can make a decision about how you'd divide your money if playing with a woman (who you do not know); if playing with a man (who do you not know); and if playing with your own spouse. Please make your decisions privately, and I will stop by to see your basket and note down what you have chosen to do.*

You and another participant
Of your 200 Birr, how much do you wish to keep for yourself, and how much do you wish to pass to the common envelope for yourself and another participant?

If the other person is a man:
PGstr1. Keep for self: _____ birr
PGastr2. Pass to common envelope: _____ birr
PGastr3. Total: _____ birr

If the other person is a woman:
PGstr6.Keep for self: _____ birr
PGstr7.Pass to common envelope: _____ birr
PGstr9. Total: _____ birr

You and your spouse:

Of your 200 Birr, how much do you wish to keep for yourself, and how much do you wish to pass to the common envelope for yourself and your spouse?

PGsp1: Keep for self: _____ birr
PGsp2.Pass to common envelope: _____ birr
PGsp3. Total: _____ birr

Dictator game

Enumerator script*: In this activity, you have 200 birr that you can divide between an envelope for you and an envelope for another participant. Again, the blue envelope is private for you; the green envelope is now for the other participant. That is the only decision and after that the game ends.*

You will do this allocation choice three times, where the other participant will either be a randomly selected person in this session (either a man, or a woman), or your own spouse. You may choose to keep all the money for yourself and give nothing to the other participant, or to keep some and pass the remainder to the other participant. Again, no one else in will know your decisions in this, or any other activity, in the session.

We will provide some additional paper bills so your bills add up to 200 birr. Then, please allocate your bills across the envelopes in your basket. I will come and record your decision.

You and another participant
Of your 200 Birr, how much do you wish to put in your personal basket, and how much do you wish to pass to another participant's basket?

If the other person is a man:
Dstr1: Keep for self: _____ birr
Dstr2: Pass to other participant: _____ birr
Dstr3: Total: _____ birr

If the other person is a woman:
Dstr4; Keep for self: _____ birr
Dstr5; Pass to other participant: _____ birr
Dstr6.Total: _____ birr

You and your spouse
Of your 200 Birr, how much do you wish to put in your personal basket, and how much do you wish to pass to your spouse's basket?
Dsp1; Keep for self: _____ birr
Dsp2; Pass to spouse: _____ birr
Dsp3; Total: _____ birr

Enumerator script:

Thank you for participating. Please be patient as I will now calculate how much each person has earned, and prepare an envelope for each of you with your money. I will call up each person to receive your payment.

Enumerator instructions:

Open the SurveyCTO form and enter the following information for each participant. Please collaborate with the other relevant enumerator to copy and enter below the decision made by the matched stranger or spouse (the

amount this individual contributed to the common basket, or passed on to the other participant) depending up on the type of game the participant is assigned for payment determination.

R9a. If R6 = 1, please enter the amount that the matched stranger [R7] contributes to the common basket (**PGstr1**)

R9b. If R6 = 2, please enter the amount that the spouse [R5] contributes to the common basket **(PGsp2**)

R9c. If R6 = 3, please enter the amount that the matched stranger [R7] passes on to this participant (**Dstr1**)

R9d. If R6 = 4, please enter the amount that the spouse [R5] passes on to this participant **(Dsp2**)

Now, you will see that SurveyCTO is programmed to calculate the amount of the game pay-off based on the types of the game s/he is randomly assigned to. Prepare an envelope with that person's name and the right amount of funds inside.

Once the payment envelopes are prepared, invite each person up to receive the envelope and sign the receipt. Please share the following script only with each individual as you pay him/her. Note that in order to preserve the confidentiality of game decisions vis-à-vis spouses, the respondents will not be informed whether their game partner was a spouse or a randomly chosen stranger participant.

Enumerator individual script*: Thank you for joining this experimental session. We have included 100 birr to thank you for your time. For the activities, you were chosen by lottery to be paid based on the [public goods / dictator] game. Your earnings in this game were [ ] birr. Your total earnings, including the 100 birr, are [ ] birr.*