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**Gender Gaps in Sustainable Land Management and Implications
for Agricultural Productivity**

Evidence from Ethiopia

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Abstract

We investigate whether a large-scale watershed program promoting sustainable land management (SLM) in Ethiopia increases adoption of SLM and its benefits on plots owned by women in male-headed households compared to plots owned by their spouses, jointly owned plots as well as plots of female headed households (FHH). The analysis is based on a survey of 500 households and 2900 plots conducted in the Abbay basin of Ethiopia where the SLM program was implemented between 2012 and 2017. Our findings show that the SLM program significantly increased adoption of SLM practices (soil bunds, stone terraces, mulching) in male-headed households but that adoption was centered on jointly owned plots and male-owned plots, with no significant adoption on women-owned plots. The results also show that women in male-headed households are more constrained to participate in SLM programs compared to their counterparts in FHH. Results further show that although FHH were less likely than male-headed households to adopt SLM in watersheds with no SLM interventions, the SLM program significantly increased adoption of soil bunds on plots in FHH. SLM adoption and impacts can likely be further strengthened if a focus on removing women's constraints is added.

Key Words: Sustainable land management, Gender inequalities, Women's plots, Soil bunds, Stone terraces, Ethiopia.

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1. Introduction

The literature on agricultural productivity has documented large gaps in productivity between plots managed by men and those managed by women (Quisumbing et al. 2014). FAO (2011) reports that across a wide set of crops and countries, the gendered yield gap is about 20-30 percent, with most of this gap accounted for by differences in resource use. Several other studies corroborate both differences in productivity levels of farms managed by men and women, and differences in the use of modern inputs by male and female farmers as major contributors to the yield gap (Djurfeldt et al. 2013; Sheahan and Barrett, 2017).

In this paper, we investigate gender differences in the adoption of sustainable land management (SLM) practices and investments and the role differential adoption has in explaining differences in productivity of plots owned by men and women. Key SLM practices in Ethiopia include soil bunds, stone bunds, drainage ditches, mulching and the application of manure. Stone bunds and terraces are structures commonly built to control runoff and thus increase soil moisture and reduce soil erosion. However, constructing continuous bunds to protect broad tracts of land is costly and often difficult, so alternative methods of erosion control, such as soil bunds, and for soil moisture management, such as mulching or applying manure are also employed (Kato et al. 2019; Kato et al. 2011).

We analyze differences in the adoption of SLM and its impact on productivity on plots owned by women in male headed households compared to plots owned by their spouses, jointly owned plots, as well as plots managed by female headed households. In so doing, this paper contributes to our understanding of sources of gendered yield gaps. According to FAO (2011), closing the

yield gap between men's and women's farms can increase agricultural output in developing countries by 2.5 to 4 percent and could reduce the number of undernourished people in the world in the order of 12–17 percent. Hence, efforts to understand sources of yield gaps that go beyond the usual narrative of differences in the use of inputs is expected to be helpful to broaden the toolkit that policymakers can use to reduce the gender yield gap.

2. Materials and Methods

2.1 Location

This paper uses data from a household-plot survey conducted in the Amhara region of Ethiopia in 2017. Since 2012, the Water and Land Resources Center (WLRC) of Addis Ababa University, with financial support from several development partners, has promoted SLM interventions in six watersheds in the Amhara region of Ethiopia. The data were collected by a joint effort of three institutions, including the International Food Policy Research Institute (IFPRI) leading the study design, the Water Land Resource Center of Addis Ababa University (WLRC) leading field data collection, and Oxford University in the UK providing the overall inputs to link SLM approaches with gendered outcomes under a global program for improving water security for the poor (REACH). The survey sample covered data collection from two learning watersheds where the SLM program was promoted and two control watersheds where the program was not implemented.

The selection of control watersheds and treatment watersheds was based on similar biophysical characteristics to avoid potential selection biases that could confound the study findings and limit

external validity. Plot ownership was derived from a survey question on plot ownership by gender. Other questions included information on the sustainable land management practices on each plot, characteristics of each plot (land size, plot depth, soil fertility), crops grown and production levels on each plot.

2.2 Empirical Approach

The empirical approach includes both descriptive analysis and cross-sectional econometric analysis. Descriptive analysis was used to highlight the differences in characteristics between women-owned plots, men-owned plots and jointly-owned plots in terms of plot size, land quality (farmers subjective perceptions of soil depth and fertility), crops grown on the plots, SLM practices on the plots, and the distribution of these plots by gender of household head. We then use econometric analysis to identify the impact of the SLM program on adoption of SLM practices on these plots, controlling for several sources of confounders that could arise from differences in household characteristics and differences in plot characteristics.

The main purpose of the econometric analysis is to estimate the treatment effects of the SLM program in the learning watersheds (treated group) compared to control watersheds (counterfactual group) regarding adoption of SLM practices and how these treatment effects differed on women's plots when compared with men's plots and joint plots. Because the design of the intervention in the learning watersheds was non-experimental (non-randomized control trial), we use a non-experimental econometric identification approach to estimate SLM program impacts. We constructed the key variable of interest "SLM program variable" as a dichotomous treatment variable that was then used in the analysis. The "SLM program" treatment variable

was created as an intent-to-treat construct with value 1 (for all households in the learning watersheds) and a counterfactual value of 0 (for all households in the control water sheds). Therefore, in all regression estimations, the SLM program variable and its associated parameter estimate compares the difference in adoption levels between households in the treated learning watersheds with households in the control households.

The econometric approach adopted in this paper is intended to test and answer four empirical questions examined through four econometric estimations. In the first regression, we estimate whether the SLM program significantly increased adoption of SLM on plots in male-headed households compared to plots of female-headed households. The second regression estimation limits the analysis to male-headed households and tests whether the SLM program increased adoption of SLM practices in women-owned plots compared to men-owned and jointly owned plots. The third regression estimation uses the full sample and tests whether there are differences in SLM adoption between women's plots in female-headed households and women's plots in male-headed households. The fourth regression estimation tests whether adoption of the main practices in the field on women-owned plots, i.e. soil bunds and stone terraces, improves crop productivity and therefore women's welfare.

In all regressions, we control for the household- and plot-level characteristics that have been found in the empirical literature in Ethiopia and elsewhere in Africa to determine adoption of land management practices and crop productivity (e.g. Adesina and Chianu 2002; Freeman and Coe 2002; Kazianga and Masters 2002; Mekuria and Waddington 2002; Place, et al. 2002; Nkonya, et al. 2004; Benin 2006; Jagger and Pender 2006; and Pender and Gebremedhin 2007).

Household-level characteristics we controlled for in the regressions include household labor endowments (number of adult women and number of adult men), household human capital (age of household head, gender of household head, household size, and education level of household head), household poverty status (type of roofing material and type of floor material), household asset endowments (number of oxen and number of donkeys). Controlled for plot-level characteristics include land quality (perceptions of soil depth), distance of the plot from the homestead, slope of the plot, subjective perceptions of plot soil quality, plot size, use of irrigation, crop choices grown on the plot, gender of plot's owner (women-owned plots, men-owned plots, jointly-owned plots). Although land tenure security has been promoted by the Ethiopian government through its land certification program, allowing formalization of land rental and sharing contracts (Gebrehiwot and Holden,2020), we did not control for land tenure effects. The majority of plots were reported as owned (90% of the plots), with less than 1% of plots reported as rental tenure and about 5% reported as shared crop tenure. Surprisingly, no rental arrangement was reported on men's plots and women's plots; the few rental tenure arrangements were on joint plots. The data suggest that land rental markets and share cropping contracts were still under development in the study watersheds. We therefore we did not control for their effects, as a single land tenure system dominated.

In all the regression estimations, we were able to correct for the possible endogeneity of the placement of the SLM program in the intervention watersheds through the double robust estimator approach that involves weighting all regressions using inverse probability weighting based on propensity scores to reduce selection bias (see Hirano and Imbens,2001; Kang and Schafer, 2007; Robins et. al, 2007; and Wooldridge 2010). However, we have not accounted for

the potential endogeneity of the gender of plot-ownership due to the cross-section nature of the data and difficulty of finding credible excluded instruments. Therefore, the results on the relationship between the gender of the plot owner and SLM adoptions need to be taken as correlations and suggestive evidence rather than causal linkage. The rest of this section provides details on the econometric specifications of these four regression estimations.

To econometrically test if participation in the SLM program had an impact on adoption of the various SLM practices overall and whether or not this adoption differs on plots in male-headed households versus plots in female-headed households, we create an interaction term between the gender of the household head and the SLM program and we estimate the empirical model shown in equation (1) below.

$$\text{SLM adoption} = f(\text{SLM Program} \times \text{gender of household head}, \text{SLM Program}, \text{gender of household head}, \text{exogenous household factors}, \text{exogenous plot factors}, \text{error term})$$

..... (1)

The dependent outcome variable of SLM adoption focuses on five SLM investments and practices - namely soil bunds, stone terraces, drainage ditches, mulching, and manure application. Since these dependent outcome variables are measured as discrete and dichotomous in nature, we estimate the models using the non-linear maximum likelihood limited dependent variable model, i.e., the Probit regression estimator (Long, 1997; Powers and Xie, 2008; Cameron and Trivedi, 2010; Green, 2012). All the model regression functions are estimated with robust standard errors using the White-Huber sandwich estimator (White, 1980) that adjusts for heteroscedasticity of unknown form.

We estimate the presence of differential adoption of SLM investments and practices on women-owned plots compared to male-owned and jointly owned plots in male-headed households by restricting the estimation sample to plots in male-headed households. We included interaction terms between the gender of the plot owner and the SLM program as shown in equation (2) below for women-owned plots and male-owned plots. The interaction with women-owned plots is used as a reference group. We estimate the empirical model as specified below:

$$\text{SLM adoption} = f(\text{SLM Program, Jointly owned plots, Men owned Plots, } \mathbf{SLM Program X Jointly owned plots, SLM Program X men plots, exogenous household factors, exogenous plot factors, error term}) \dots\dots\dots (2)$$

To test whether there are differences in SLM adoption between women’s plots in female-headed households and women’s plots in male-headed households, we revert back to the full sample and estimate the model with women-owned plots as a reference group and the remaining three groups (male-owned and jointly-owned plots in male-headed households and women’s plots in female-headed households) included in the estimation. The estimated model is shown in equation (3).

$$\text{SLM adoption} = f(\text{SLM Program, plots in female headed households, Men owned Plots, Jointly owned plots, } \mathbf{SLM Program X plots in female headed households, SLM Program X men plots, SLM Program X joint plots, exogenous household factors, exogenous plot factors, error term}) (3)$$

We estimate the impact of adopting soil bunds and stone terraces on crop productivity of plots owned by women in male-headed households by estimating a production function on a sample

restricted to male-headed households. The value of crop production in *Birr* per ha is the dependent outcome variable and we introduce interaction terms between soil bunds and stone terraces with gender of plot owner on the right-hand side of the production function as explanatory variables as shown below in equation (4). Women-owned plots are used as a reference group and the remaining three groups and their interaction with the SLM program are included the estimation.

Value of Crop productivity = f (Soil bunds X joint plots, Soil bunds X men plots, Stone terraces X joint plots, Stone terraces X men plots, Soil bunds, Stone terraces, men plots, joint plots, SLM program, exogenous household factors, exogenous plot factors, error term) (4)

Because the value of crop production as the dependent variable is a continuous outcome, we estimate equation (4) using an ordinary least squares estimator. Compared to a production function estimate, the error term in the OLS estimate is likely to be biased but unlike efficiency and productivity models, the intercept term is not the main variable of interest in this paper. We transformed the value of crop production into a logarithmic transformation which has several advantages of reducing sensitivity to outliers, reduces heteroscedasticity, and creates normal distribution (Mukherjee et al. 1998).

3. Results

3.1 Descriptive Results

Male-headed households control the majority of the plots, at 94% of the plots (2376 plots), while 151 plots are managed by FHH. As one would expect, the majority of the plots (89%) in FHH are women-owned, while 10% are jointly owned with adult children and 1% of plots are owned by

men (Figure 1). In male-headed households, most plots are jointly owned (82%), 11% are male-owned and 7% are female-owned plots.

Descriptive results further indicate that women-owned plots and jointly owned plots are perceived to have poorer soil quality compared to male-owned plots (Figure 2 and Table 1). This is also consistent with the finding that more men-owned plots are perceived to have deeper soils compared to women-owned plots and jointly owned plots. These results suggest that men-owned plots appear to be better in terms of land quality than women- and jointly owned plots. The gender inequality in land quality provides the motivation for the econometric analysis undertaken in this paper to empirically test the role of SLM in female- versus male-owned plots.

Men-owned plots are slightly larger than women-owned plots and jointly owned plots in male headed households, although the difference is small and statistically not significant.

Maize is the most common crop on all plots, but it is more common on women-owned plots than on men-owned and jointly owned plots (Figure 3 and Table 1). *Teff* is also a common crop but most common on women-owned and jointly owned plots.

The most common SLM investments are stone terraces and soil bunds, and the most common SLM practices are mulching and manure (Table 2). Stone terraces are more common on women-owned plots and jointly owned plots while soil bunds are most common on men-owned plots. Mulching is mostly used on men-owned plots while manure is mostly used on women-owned and jointly owned plots. The higher prevalence of stone terraces on women-owned plots than on men-owned plots is possibly because soil erosion is a more serious problem on women plots,

which is consistent with our finding that women's plots are perceived to have less deep soil when compared to men-owned plots. The larger use of mulching on men-owned plots could be because men-owned plots tend to have more coffee and mangos and perennial crops that would require mulching while women-owned plots tend to have more annual crops such as maize and teff which do not require mulching.

There is more use of SLM on women-owned plots in male-headed households than women-owned plots in FHH (Table 3) for most of the practices. We will investigate econometrically whether the SLM program contributed to these adoption levels of SLM on women-owned plots. Although FHH accounted for less than 10% of the sample, these results suggest that women in FHH faced constraints in adopting SLM compared to their women counterparts in male-headed households.

3.2 Econometric Results

The econometric results provide four inter and intra-household gender perspectives in the implementation of SLM investments and practices. Firstly, we present findings on whether the SLM program is successful in promoting SLM investments and practices and whether this effect on adoption varies by the gender of the household head. Secondly, we assess whether there is differential adoption of SLM practices on male-owned, female-owned and jointly owned plots. Thirdly, we present findings on whether SLM adoption on women-owned plots varies between FHH and male-headed households. Fourthly, we will present findings on whether adoption of SLM gets translated into yield gains.

Table 4 presents the impacts of the SLM program on the adoption of key SLM practices. Results show that adoption of soil bunds in treated learning watersheds was 20% higher, adoption of stone terraces was 5% higher and mulching was 5% higher. Programmatic impacts prevail with and without controlling for possible bias from endogenous selective placement of the SLM program intervention as shown in the Probit regressions and PSM weighted Probit regressions. Furthermore, the SLM program impacts of increasing adoption of SLM remained robust when we controlled for differences in crop choices (Table 4) and when we excluded crop choices (results not reported in Table 4 but available from the authors on request). These findings demonstrate that the watershed-level SLM program improved household-level use of SLM practices or investments.

Table 5 present findings on differential adoption of SLM on women-owned plots, men-owned plots, and jointly-owned plots in male-headed households. Intra-household analysis of impacts is important to understand if the SLM programs in the country should consider special means reaching women farmers. The key finding from the analysis is that the SLM program significantly increased adoption of SLM practices on men-owned and jointly-owned plots compared to women-owned plots. Furthermore the analysis also shows that the program significantly increased adoption of soil bunds and stone terraces on jointly owned plots (the most common type of plot ownership) where women were involved as co-owners. These results therefore suggest that male-owned and jointly owned plots gained significantly more than women's plots in male-headed households. Women benefitted more from joint plots than from solely-owned plots.

These findings are not sensitive to the estimations being adjusted for potentially endogenous selection of watershed for inclusion into the SLM program. The results are also similar whether or not we control for crop choices on the plots. The latter are again available upon request from the authors.

Although the adoption impacts were largest on soil bunds and stone terraces, the SLM program also increased adoption of other less common SLM practices such as construction of drainage ditches and mulching.

This evidence highlights the potential gender inequalities in households from agricultural programs, such as SLM programs if gender perspectives are not integrated in the project programming.

Table 6 presents differences in the adoption of SLM practices between women's plots in FHH and in male-headed households. This is important to inform us whether the gender of the household head affects the level of adoption of SLM practices on plots above and beyond the gender of the plot owner. The estimation is done on the whole sample (male-owned, female-owned, and jointly-owned plots in male headed household and plots in FHH households) but the interpretation of the results focuses on the comparison between the levels of SLM adoption between women in male-headed households and that of FHH.

The results in Table 6 show that women-owned plots in male-headed households are at a disadvantage in SLM adoption compared to plots in FHH. That is, women-owned plots in male-headed households are less likely to have SLM investments and practices, not only compared to

men-owned and jointly-owned plots in their own households, but also compared to women in FHH. The difference in the adoption rate of SLM between men-owned plots and women-owned plots in a male-headed household are about the same in magnitude as the difference in SLM adoption between women's plots in male- and female-headed households. These findings suggest that the constraints women face to adopt SLM are more limiting to women in male-headed households than to women in FHH.

Our final analysis examines whether the disadvantage of women-owned plots in the adoption of SLM investments and practices compared to men-owned and jointly-owned plots in their household as well as compared to plots in FHH translates into a disadvantage in farm productivity, which is a key pathway through which SLM can influence households' and individuals' welfare.

To test this econometrically, we interact the gendered plot ownerships with soil bunds and stone terraces as explanatory variables in a productivity equation while controlling for several household- and plot-level characteristics. We estimate a linear OLS regression with the log of the value of crop production expressed as Birr (Ethiopian currency) per hectare as the dependent variable.

The results presented in Table 7 show that adopting SLM significantly increases crop productivity and therefore SLM has potential to reduce rural poverty in Ethiopia. Specifically, plots that have soil bunds and those that have stone terraces on steep slopes have significantly higher crop productivity compared to plots without these SLM practices. The impact of soil bunds on crop productivity is seen on plots in both male-headed households and FHH, while the impact of stone

terraces is seen on women's plots in male-headed households. These findings suggest that when SLM (soil bunds and stone terraces) has been adopted by women, it significantly boosts women's crop productivity. Thus, low levels of adoption of SLM on women-owned plots in male-headed households are likely to be one of the drivers of gendered yield gaps, in addition to the lower use of modern inputs. Removing bottlenecks that might impede women's access to and benefit from SLM practices might be one avenue to increase the impact of such programs.

4. Discussion

In this paper, we have investigated whether an SLM promoting program implemented in the Amhara Region of Ethiopia increased adoption of SLM investments and practices on women-owned plots in male-headed households, compared to men-owned and jointly-owned plots in their households as well as compared to plots in FHH. We have also investigated the effect of SLM adoption on farm productivity at plot level.

The analysis gives rise to four major findings on the gender implications of the SLM program. Firstly, the SLM program significantly increased adoption of SLM investments and practices in watersheds in which it was implemented but there is no significant difference in the levels of adoption between male-headed and female-headed households. Second, within-male headed households, adoption of SLM investments and practices occurred more so on men-owned and jointly owned plots, and to a lesser extent on women-owned plots. Third, the SLM adoption on women-owned plots in male-headed households is much lower than on plots in FHH. Fourth, wherever adopted, SLM investments (particularly stone terraces and soil bunds) have significant

productivity enhancing effects. The low level of adoption of SLM investments and practices on women-owned plots in male-headed households is a contributor to gendered yield gaps.

In conclusion, SLM programs operating in rural areas in Ethiopia or other developing countries with relatively similar land ownership structures and gendered relations would benefit from integrating intra-household gender considerations in project programming to enhance program outcomes and to contribute to the reduction of gendered yield gaps between plots owned by men and women.

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TABLES

Table 1: Characteristics of Women-owned, Men-owned and Jointly Owned Plots

	Women Owned Plots (N=291)	Men Owned Plots(N=261)	Jointly Owned Plots (N=1975)	Test mean equality (P-value)
% Plots Male Headed Household	53.6	99.6	99.2	0.000***
% Plots Female Headed Household	46.4	0.4	0.8	0.000***
Mean Plot Size (ha)	0.22	0.23	0.22	0.936
% Plots with Maize	35.1	29.8	29.9	0.220
% Plots with Teff	12.0	8.4	11.3	0.330
% Plots with Sorghum	0.6	2.3	1.6	0.305
% plots with Hops (<i>Gesho</i>)	10.9	11.4	10.3	0.815
% Plots with Finger millet	17.2	17.2	18.7	0.815
% Plots with Coffee	1.3	3.8	4.3	0.055**
% Plots with Chat	12.0	11.1	12.4	0.843
% Plots with Mango	1.3	3.1	2.4	0.239
% Plots perceived to have Poor Soil Quality	11.7	8.4	10.6	0.437
% Plots perceived to have Good Soil Quality	40.2	39.8	38.3	0.764
% Plots perceived to have Medium Soil Quality	48.1	51.7	50.9	0.620
% plots with Very Deep Soils	31.9	42.5	39.6	0.020**
% plots with Medium Deep Soils	44.7	45.9	43.7	0.774
% plots with shallow Deep Soils	0.0	0.7	1.2	0.129

Table 2: Distribution of SLM Investments and Practices on Plots in Male-headed Households

Plot Ownership type	Stone Terraces	Soil Bunds	Drainage Ditches	Dams	Trenches	Mulching	Manure
Men-owned	12%	36%	2%	0%	0%	29%	33%
Jointly owned	16%	30%	7%	1%	0%	21%	35%
Women-owned	23%	34%	3%	0%	0%	21%	47%
Test Difference	0.007***	0.167	0.008***	0.524	0.427	0.015**	0.011***

Table 3: Use of SLM investments and Practices on Women-owned Plots in Male headed Households and Female Headed Households

	Stone Terraces	Soil Bunds	Drainage Ditches	Dams	Trenches	Mulch	Manure
Women Plots-Male Headed Households	23%	34%	3%	0%	0%	21%	47%
Women Plots- Female Headed Households	13%	17%	8%	0%	0%	13%	27%
Test Difference	0.03**	0.001***	0.065*	NA	NA	0.081*	0.0004***

Table 4: Binomial Probit Impact Regression Marginal Probabilities Estimates predicting Impacts of SLM program on overall adoption of SLM

	Soil Bunds		Stone Terraces		Drainage Ditches		Mulching		Manure	
	Probit	PSM Weighted Probit	Probit	PSM Weighted Probit	Probit	PSM Weighted Probit	Probit	PSM Weighted Probit	Probit	PSM Weighted Probit
Female Headed Household X SLM Program	-0.07 (0.086)	-0.01 (0.096)	0.09 (0.083)	0.05 (0.090)	0.16 (0.123)	0.12 (0.112)	-0.04 (0.053)	-0.04 (0.056)	0.03 (0.068)	0.001 (0.075)
SLM Program	0.20*** (0.018)	0.19*** (0.018)	0.05*** (0.015)	0.05*** (0.014)	0.01 (0.011)	0.01 (0.011)	0.04*** (0.014)	0.05*** (0.013)	-0.002 (0.015)	0.002 (0.015)
Regression Covariates:										
Household Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Plot level Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Plot Crop Choices	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Plots	2,499	2,465	2,447	2,438	2,234	2,319	2,462	2,429	2,499	2,465
Overall Model Significance (P-Value)	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
Pseudo R-Squared	0.1198	0.1278	0.1559	0.1584	0.1627	0.1634	0.4267	0.4258	0.4393	0.4608

Note: Estimation based on Full sample of Male headed households and Female headed households. Numbers in parentheses are standard errors.

Table 5: Binomial Probit Impact Regression Marginal Probabilities Estimates predicting Impacts of SLM program on adoption of SLM on Women plots in Male Headed Households

	Soil Bunds		Stone Terraces		Drainage Ditches		Mulching		Manure	
	Probit	PSM weighte d Probit	Probit	PSM weighted Probit	Probit	PSM weighted Probit	Probit	PSM weighte d Probit	Probit	PSM weighted Probit
Reference group: Women- owned plots										
Jointly-owned plots X SLM program	0.13** (0.07)	0.17*** (0.070)	0.01 (0.05)	0.01 (0.05)	0.44 (0.51)	0.44*** (0.01)	-0.01 (0.05)	0.002 (0.05)	0.06 (0.05)	0.08 (0.06)
men-owned plots X SLM program	0.27*** (0.099)	0.32*** (0.099)	-0.01 (0.07)	0.01 (0.074)	0.82 (2.42)	0.82*** (0.016)	0.13* (0.09)	0.18* (0.111)	0.12* (0.077)	0.15* (0.085)
SLM program	0.20*** (0.02)	0.20*** (0.02)	0.06*** (0.02)	0.06*** (0.02)	-0.58 (0.65)	-0.58*** (0.005)	0.03** (0.02)	0.04*** (0.015)	-0.07 (0.05)	-0.08 (0.06)
Regression covariates:										
Household characteristic s	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Plot characteristic s	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Plot crop choices	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of plots	2,349	2,315	2,297	2,288	2,105	2,100	2,314	2,281	2,349	2,315
Pseudo R- Squared	0.1199	0.1292	0.1603	0.1636	0.168	0.1734	0.4248	0.4257	0.4399	0.4623

Note: sample restricted to Male headed Households.

***, **, * shows significance at 99%, 95% and 99% confidence intervals.

Numbers in parentheses are standard errors.

Table 6: Marginal Probabilities from Binomial Probit Estimates predicting Impacts of SLM program on adoption of SLM on Women-Owned Plots in Female- Vs Male-Headed Households

	Soil Bunds		Stone Terraces		Drainage Ditches		Mulching		Manure	
	Probit	PSM weighted Probit	Probit	PSM weighted Probit	Probit	PSM weighted Probit	Probit	PSM weighted Probit	Probit	PSM weighted Probit
Reference group: Women-owned plots in male headed households										
Women plots in FHH X SLM program	0.28*** (0.111)	0.24** (0.113)	0.20** (0.095)	0.16 (0.109)	0.20* (0.125)	0.16 (0.126)	-0.04 (0.11)	-0.01 (0.084)	0.035 (0.18)	0.06 (0.12)
Male-owned plots in male-headed households X SLM program	0.29*** (0.095)	0.34*** (0.091)	0.04 (0.059)	0.05 (0.060)	-0.03 (0.027)	-0.04* (0.023)	0.13 (0.19)	0.20 (0.177)	0.05 (0.19)	0.12 (0.15)
Joint plots in male-headed households X SLM program	0.15*** (0.065)	0.19*** (0.060)	0.50 (1.489)	0.50*** (0.010)	0.45*** (0.036)	0.44*** (0.042)	-0.01 (0.13)	0.02 (0.098)	0.004 (0.17)	0.05 (0.12)
SLM program	0.05 (0.063)	0.005 (0.060)	-0.55 (2.139)	-0.55*** (0.013)	-0.55*** (0.040)	-0.54*** (0.049)	0.04 (0.12)	0.01 (0.097)	-0.004 (0.17)	-0.05 (0.12)
Regression covariates:										
Household characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Plot characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Plot crop choices	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of plots	2,499	2,465	2,447	2,438	2,253	2,248	2,462	2,429	2,499	2,465
Pseudo R-Squared	0.12	0.13	0.16	0.16	0.17	0.17	0.43	0.43	0.44	0.46

***, **, * shows significance at 99%, 95% and 99% confidence intervals.

Numbers in parentheses are standard errors

Table 7: OLS Regressions: Impact of SLM adoption on Log Value of crop Production (Birr/ha)

	Outcome: Log value of crop production (Birr/ha)			
	All Plots	Plots in male-headed households	Plots in female-headed households	Plots in learning watersheds
Overall impacts of SLM practices on crop productivity:				
Soil bunds	0.198***	0.199***	0.830***	0.229***
Stone terraces	-0.113*	-0.123*	-0.03	-0.073
Mulching	-0.046	-0.036	-0.041	0.076
Reference group: Jointly-owned plots				
Soil bunds X women plots	0.078	0.111		0.027
Soil bunds X men plots	0.022	-0.206		0.125
Stone terraces X women Plots	0.174	0.394*		0.186
Stone terraces X men Plots	-0.128	-0.127		-0.245
Stone terraces X women-owned plots X steep slopes	-0.016	-0.199	0.053	0.077
Stone terraces X men owned plots X steep slopes	0.702**	0.761***		0.753*
Women-owned plot	-0.077	-0.052	-0.747*	-0.089
Men-owned plot	-0.134	-0.159*	-0.236	-0.116
SLM program	0.115**	0.089*	0.655***	
FHH	-0.322***			-0.059

***, **, * shows significance at 99%, 95% and 99% confidence intervals.

FIGURES

Figure 1: Distribution of Gender of Plot Owner by Gender of Household Head

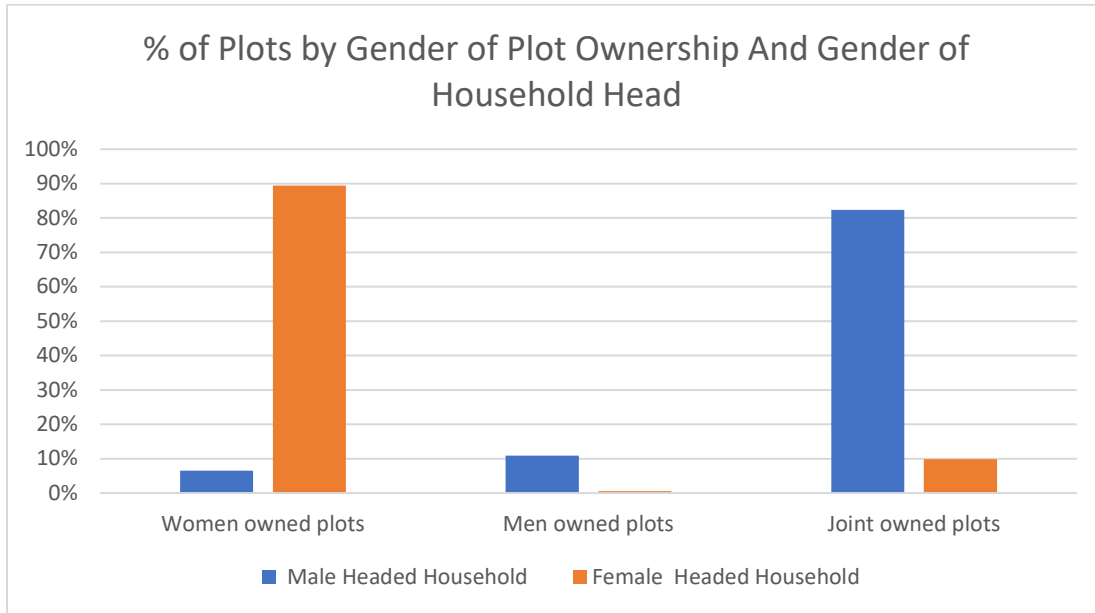


Figure 2: Distribution of Plots Perceived to have Poor Quality Soils by Gender of Plot Owner

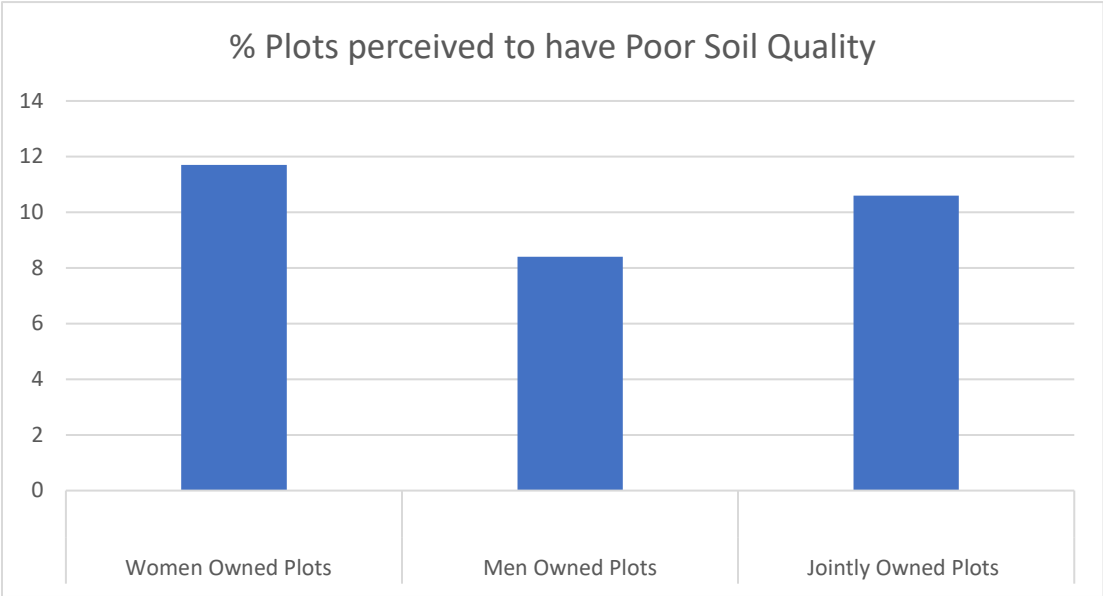
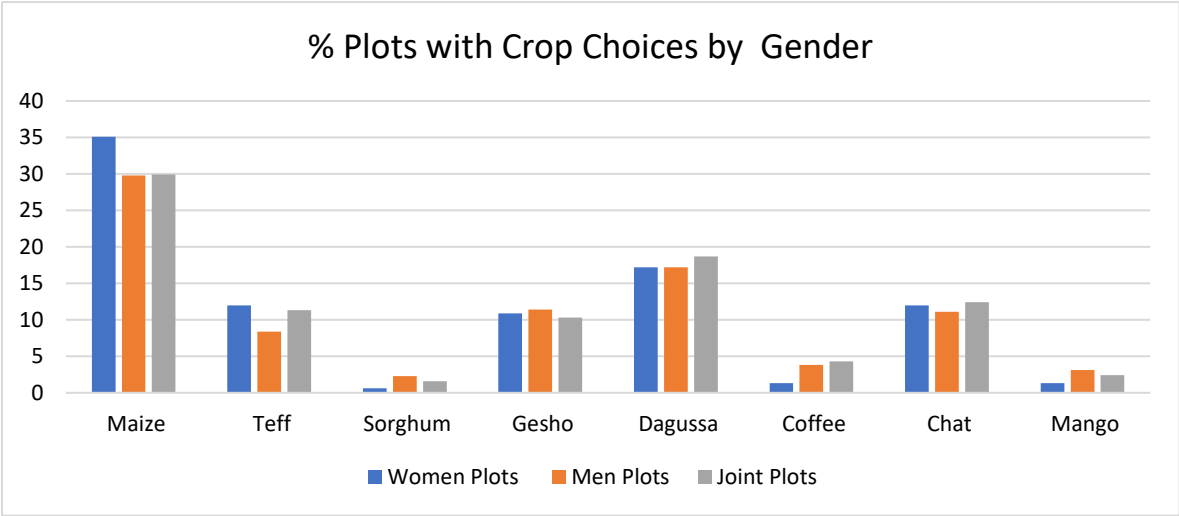


Figure 3: Distribution of plot crop choices by Gender of Plot Owner



Note: *Dagussa* is finger millet, *Gesho* is hops.

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