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Land Rights Knowledge and Conservation in Rural Ethiopia

Mind the Gender Gap

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Contents

Tables

Figures

ABSTRACT

Increasing productivity and incentives to invest in climate-smart agricultural practices are among the arguments frequently raised in favor of strengthening and formalizing land rights, particularly in areas where customary land rights prevail. In areas where women have weaker land and property rights than men, there is even greater interest in the role of policy reforms to strengthen women's property rights as a way to empower women as well as to promote other development objectives, such as increased food security and better health and nutrition for their families. The community-based land certification effort in Ethiopia has attracted much attention because it is an early successful attempt to implement a cost-effective and transparent land-registration process. Nevertheless, formal land rights are not sufficient to ensure increased investment. In order for men and women to act on newly acquired legal rights to land, they need accurate information about these rights. Using the 2009 round of the Ethiopian Rural Household Survey, this paper examines the medium-term impact of the land registration on investment behavior by households, particularly the adoption of soil conservation techniques and tree planting. It investigates whether men's and women's knowledge of their property rights under the land registration (as measured by answers to a list of questions regarding the provisions of the registration, covering such areas as tenure security, land transfer rights, and rights related to gender equity and inheritance) has an impact on these investments. We find that the difference between male- and female-headed households' proportions of land registered is small, reflecting the near-universal registration of land in our study area. However, the disparity in men's and women's knowledge about land rights is more glaring. Controlling for the household level of land rights knowledge, we find that gender gaps in knowledge about land rights in three domains—tenure security, land transferability, and gender rights—diminish the adoption of soil conservation practices as well as the planting of tree crops and legumes, although different domains of rights matter for different practices. This suggests that closing the knowledge gap in legal rights is an important step to improving adoption of soil conservation technologies and sustainable farming techniques.

Keywords: land rights, legal knowledge, gender, soil conservation practices, land certification, Ethiopia

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1. INTRODUCTION

Increasing productivity and incentives to invest in tree planting and soil conservation techniques (SCTs) are among the arguments frequently raised in favor of strengthening and formalizing land rights, particularly in areas where customary land rights prevail. Deininger, Ali, Holden, et al. (2008), in their paper on the initial impact of the land certification in Ethiopia, mention the following benefits of land registration/documentation: the ability to draw on formal mechanisms to enforce property rights, incentives for land-related investment, enhanced gender equality and bargaining power of women, improved governance, reduced conflict potential, and lower transaction costs for productivity-enhancing land transfers through rental or sale. Using data from a nationwide survey conducted in July and August 2006, three years after the start of community land registration, Deininger Ali, Holden, et al. (2008) found that while the registration process was not biased against the poor, female participation was lower than male participation in the early stages of the registration, and only a fifth of land administration committees (LACs), on average, had a female member, even if this was required. Their study also found positive initial impacts on households' undertaking new land-related investments, specifically tree planting and adoption of SCTs, in the past 12 months. These findings are important because integrated soil fertility management, achieved through measures such as SCTs or agroforestry, has been identified as a key element of climate-smart agricultural strategies identified for East Africa (see, for example, Bryan et al. 2013).

Although land registration is now widespread throughout Ethiopia, it has often been argued that men and women need to be aware of their legal rights so that stronger land rights will change behavior—that is, formalization of land rights is not a sufficient condition for increased investment to take place (Deininger, Ali, and Yamano 2008). Prior to the land registration, men had stronger traditional control and use rights to land than women (Fafchamps and Quisumbing 2002; also see Kumar and Quisumbing 2012b). Moreover, within Ethiopian households, control of productive assets, including land, is typically vested in the household head. Although the registration equalized men's and women's rights, because plots of land were to be registered in the husband's and wife's names in most regions, the gap in women's participation relative to men's in the initial stages of land registration may have caused women's knowledge of their land rights after certification to continue to lag behind men's. If we assume that men and women share knowledge within the household, it does not matter whether one household member is aware of his or her land rights. However, accumulating evidence has challenged the assumption that knowledge—like other resources—is freely shared among individuals within the household (for example, Hoel 2012). It is also possible that the initial impact of the land registration on the adoption of SCTs may not be sustained. We revisit these issues using data collected in 2009, six years after the start of the land registration process.

This paper builds on the earlier work by Deininger, Ali, Holden, et al. (2008) in Ethiopia by examining the *medium-term* impact of the land registration on investment behavior by households, particularly the adoption of SCTs and tree planting. It examines whether men's and women's knowledge of their property rights under the land registration (as measured by answers to a list of questions regarding the provisions of the registration) has an impact on these investments. We attempt to unpack the "bundle of rights" under the land registration into three categories: tenure security, land transfer rights, and rights related to gender equity and inheritance. It attempts to answer the following questions:

1. Are men and women equally knowledgeable about their postregistration land rights, and do men's knowledge and women's knowledge of their rights differ across domains of these rights?
2. Are there gender differences in the use of soil conservation technologies and adoption of agroforestry?

3. Do gender differences in knowledge of property rights *within the same household* and *across different bundles of rights* have a differential impact on tree planting and soil conservation at the household level?
4. Do gender differences in property rights knowledge have a differential impact on tree planting and soil conservation, at the plot manager, across male- and female-managed plots?

Answering these questions will contribute to the growing literature on the role of legal knowledge in enabling women to benefit from interventions that strengthen their property rights and increase adoption of climate-smart agricultural practices.

2. BACKGROUND AND MOTIVATION

Tenure Security, Gender Differences, and Soil Conservation

A large body of literature (for example, Banerjee, Gertler, and Ghatak 2002; Bardhan and Mookherjee 2009; Feder et al. 1988; and Feder and Nishio 1997) shows that providing tenure security among users of land (owners or sharecroppers) increases productivity. Such security improves the incentives to invest in land and increases the users' ability to obtain credit. One of the pathways through which increased land tenure security is hypothesized to improve agricultural productivity is investments in soil conservation. Deininger, Ali, and Yamano (2008), for example, show that land improvements in Uganda in the form of tree planting and soil conservation have a strong positive effect on the productivity of land use; both tree planting and soil conservation are significantly affected by transfer rights and legal knowledge of land rights, respectively. Aside from their positive impacts on productivity, soil and water conservation measures are also being promoted as a key strategy to alleviate growing water shortages, worsening soil conditions, and drought and desertification and to adapt to the negative impacts of climate change (Kurukulasuriya and Rosenthal 2003, cited in Kato et al. 2011). In Ethiopia, Kato et al. (2011) find that soil and water conservation technologies have significant impacts on reducing production risk, but the selection of these technologies should be location specific, depending on a farm's biophysical characteristics.

Increasing women's land tenure security may also increase agricultural productivity. Many studies have documented productivity differentials between male and female farmers, particularly in Africa south of the Sahara. In some cases, these productivity differentials stem from women's insecure rights to land, which exacerbate the inefficiencies created by imperfect land markets. In Ghana, Goldstein and Udry (2008) attribute the productivity differential among male and female farmers to women's higher level of tenure insecurity, which renders them less likely to leave their land fallow since they risk losing the land if they are not actively farming it. Imperfections in land rental markets create productivity differentials that are not gender neutral: not only is productivity lower on female-headed households' land, but female household heads also tend to rent out their land to tenants with much lower productivity (Holden and Bezabih 2009). Indeed, Holden and Bezabih (2009) find significantly higher levels of inefficiency linked to contracts of female landlords with in-law tenants, owing to the difficulty of evicting one's relatives and the high transaction costs of screening and selecting better tenants. An important policy implication of this analysis is that strengthening women's land rights may improve both equity and the efficiency of land use.

Strengthening women's land rights may therefore result in productivity gains through two pathways: first, by increasing the probability that women adopt soil conservation technologies and, second, by removing productivity differentials associated with insecure tenure. Whether differences exist between men and women in the adoption of soil conservation technologies is an empirical question. Studies on tree planting for perennial cash crops (see Hill and Vigneri 2014 on cocoa in Ghana and coffee in Uganda, and see Quisumbing et al. 2001 on cocoa in Ghana) do not find that female farmers are consistently disadvantaged, possibly because underlying gender norms and land tenure regimes are quite different across countries studied.[1] A review of factors likely to affect the adoption of improved fallow,

[1] A study conducted in Ghana in the late 1990s (Quisumbing et al. 2001) found that there was no significant difference between male and female parcel owners with respect to tree planting but that controlling for differences in land tenure and accounting for parcel-level heterogeneity, female parcel managers obtain lower yields on their cocoa plots, although this negative effect was only weakly significant. A more recent study of cocoa farmers in Ghana (Hill and Vigneri 2014), based on surveys conducted in 2002 and 2004, finds that while women farmers remain a minority group among smallholders engaged in the cultivation of these crops, conditions for female cocoa growers are changing. The progressive, more individualized evolution of land rights has allowed women to obtain control over land, which they now increasingly plant with cocoa. In line with what is known in the literature (Quisumbing 1996; Peterman, Behrman, and Quisumbing 2014), once input levels are controlled for, female-managed farms are as productive as male-managed ones. However, in Uganda, Hill and Vigneri (2014) find that female-headed households sell smaller quantities of coffee (as a result of owning fewer trees and producing less coffee) and engage in less value addition (transporting to market, milling) than male-headed households. While part of the reason may be that female-

biomass transfer, and intercropping technologies found that in 8 out of 10 studies in Kenya, Zambia, Uganda, and Malawi, gender did not influence the use of soil fertility technologies for soil management (Kiptot and Franzel 2011).[2] More recent work on agroforestry-based fertility management technologies (Sinja, Kiptot, and Place 2012) finds that while men and women may express different interests and preferences related to soil fertility technologies (for example, women in Malawi tend to prefer species that are also food crops), differences in adoption rates are more likely tied to differences in control of land and labor resources. Women tend to be active in the planting and management of trees for enhancing soil fertility because such trees are seen as inputs into food production rather than as investments in themselves (as in timber woodlots). If control of land and labor is a constraint that is faced more by women than men, one might expect that strengthening women's control of land may lead to better adoption of such SCTs as building bunds, contouring, and using agroforestry and that labor-constrained households may be less likely to adopt more labor-intensive SCTs.

The Ethiopian Land Certification

The community-based land certification effort in Ethiopia has attracted much attention because it has been one of the few successful attempts to implement a cost-effective and transparent land registration process. Deininger, Ali, Holden, et al. (2008) point out that the decentralized nature of the land registration process and consistent adherence to procedures accelerated its implementation and that the beneficiaries viewed the process as valuable. Following the implementation of the land registration process, female heads of households in Tigray were more likely to rent out land because tenure security increased their confidence in doing so (Holden, Deininger, and Ghebru 2007). The Ethiopian land certification scheme is noteworthy because LACs at the *kebele* level (the smallest administrative unit in Ethiopia) were required to have at least one female member and land certificates were issued after public registration for transparency (Deininger, Ali, Holden, et al. 2008). The land certificates included maps and, in some regions, photos of the husband and wife.[3] Holden, Deininger, and Ghebru (2007) argue that land certification had a greater impact on women's participation in the land market because land certificates may be more valuable to women, whose tenure rights were previously less secure than those of men. Nevertheless, gaps remained in awareness and information about the process. A related study (Holden and Tefera 2008) found that, on average, women's knowledge and participation in the land registration process was lower than those of men in Oromiya and Southern Nations, Nationalities, and People's Region (SNNPR).

Deininger, Ali, Holden, et al. (2008) examined the impact of the land registration process using data collected three years after its implementation. Because of the potential long-term impact of strengthening land tenure rights, we fielded a module to study the longer-term impact of the land registration in the 2009 round of the Ethiopian Rural Household Survey, described below. We are especially interested in the gendered impacts of the land certification because the first decade of the 2000s witnessed a number of reforms that promote gender equality, including the reform of family law and the land registration. Kumar and Quisumbing (2012b) point out that these reforms, although seemingly unrelated, may have mutually reinforcing beneficial effects that may have longer-term impacts. For example, changes in the distribution of property after divorce resulting from the reform of family law that are more favorable to wives have the potential to improve investments in girls' schooling, which would help to close the persistent gender gap in educational attainment (Kumar and Quisumbing 2012a).

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headed households have less labor and thus have to prioritize diverse tasks, Hill and Vigneri (2014) also find that they own fewer transportation-related assets (bicycles) for transporting coffee to market.

[2] "Improved fallow" refers to the intentional planting of a fallow species. Improved fallows are more efficient than natural fallows and can normally achieve the same effect on crop productivity in a much shorter time. Biomass transfer systems are those in which organic nutrient sources are grown in one place and then transferred to crops in another (Place et al. 2007).

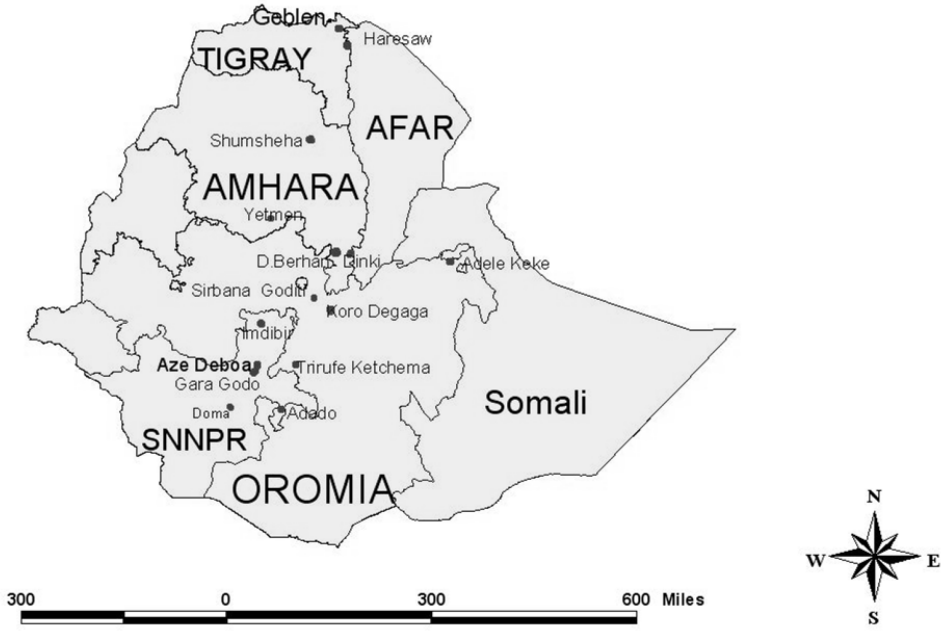
[3] Having photos instead of signatures may make it more difficult for husbands to sell or rent out land without their wives' consent; photos are also more meaningful in a society with very low literacy rates.

3. DATA AND DESCRIPTIVES

The Ethiopian Rural Household Survey

The Ethiopian Rural Household Survey is a panel dataset with seven rounds of data collection. The data collection was coordinated by the economics department at Addis Ababa University in collaboration with the Centre for the Study of African Economies at Oxford University and the International Food Policy Research Institute. For this paper we use the data from the 1997, 2004, and 2009 rounds. This gives a sample of about 1,300 households in 15 villages across Ethiopia. Although the 15 villages included in the sample are not statistically representative of rural Ethiopia as a whole,[4] they are quite diverse and include all major agroecological zones and ethnic and religious groups. The location of the sample villages is shown in Figure 3.1. About a third (32 percent) of sample households are female headed, although there is wide variation across the survey villages (Figure 3.2). The highest rates of female headship are found in the two Tigray sites (Haresaw and Geblen), possibly because of the civil war that affected this area, and the lowest is in Yetmen.

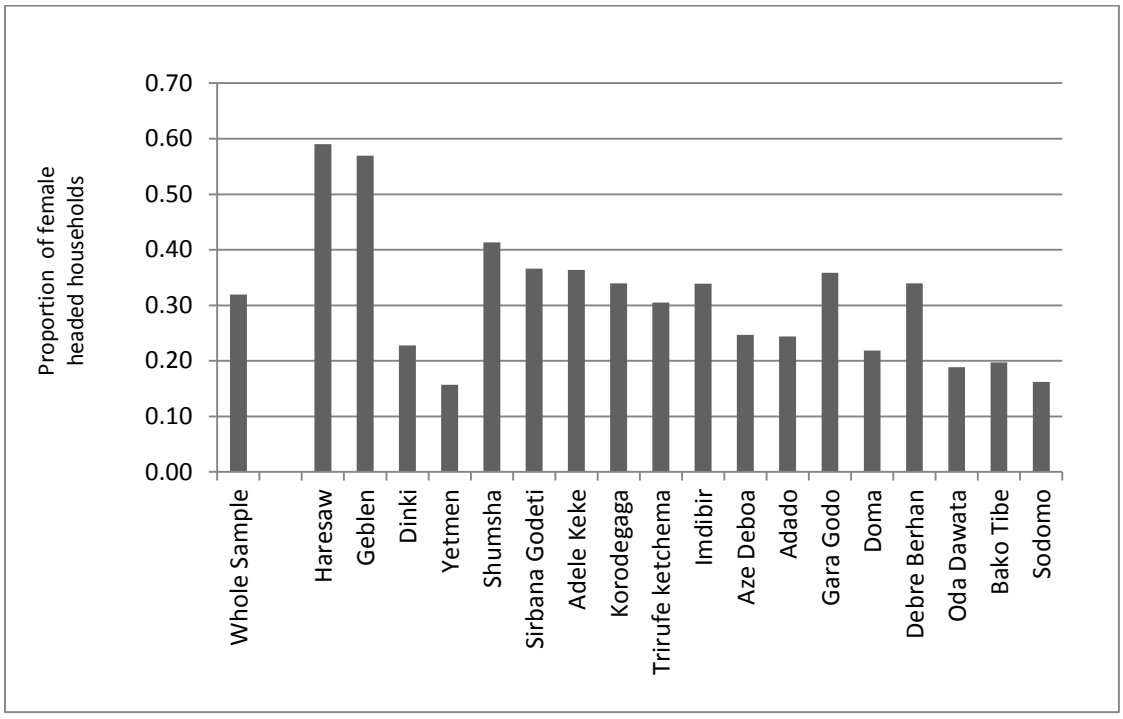
Figure 3.1 Location of the Ethiopian Rural Household Survey villages



Source: Ethiopian Rural Household Survey (2011).

[4] The ethnic and religious mix of the sample, for instance, does not match what we know of rural Ethiopia: Oromos are underrepresented; Protestants are overrepresented. The small number of Oromo sites is in part due to civil unrest at the time when the initial sample was drawn. Several villages from the Oromo region have been added to the 2000 survey round.

Figure 3.2 Proportion of female-headed households, 2009



Source: Ethiopian Rural Household Survey (2011).

The surveys collected information about household demographic characteristics, occupation, land tenure, cropping patterns, perceptions of poverty and well-being, experience with shocks, access to credit, and so forth. The land module enables us to identify which household member is responsible for managing a specific plot (with joint management allowed) and whether the plot has been registered. The survey also includes information about various land management measures, including the adoption of SCTs and tree planting. In the 2009 survey, questionnaire modules were also specifically designed to examine the gender impacts of the land registration process, asking questions about household heads' knowledge of and participation in the land registration. Questions about the provisions of and rights under the land registration were also administered separately to the male and female respondents within the same household—correct answers to these can vary because of regional differences in the provisions of the land registration. We also draw on questions about family background and assets at marriage that were administered in the 1997 round focusing on intrahousehold issues in an attempt to understand the determinants of gender differences in knowledge scores.

Awareness of and Participation in Land Certification by Male- and Female-headed Households

Male- and female-headed households differ in terms of human and physical assets, land owned and cultivated, and awareness of and participation in the land registration process (Table 3.1). Female heads of households tend to be older, have fewer years of schooling, and have household members with fewer completed years of schooling than do male household heads. Female-headed households also have a larger share of dependent members but a smaller household size. They tend to have less livestock, be less likely to belong to an *iddir* (a burial society, which is an important form of social capital and insurance in rural Ethiopia), and have fewer sources from whom they can borrow.

Table 3.1 Human and physical assets of female- and male-headed households, 2009

Human or physical asset	Female-headed household	Male-headed household	*p* value
Age of head	54.28	52.53	**
Education of head	0.33	2.22	*
Highest grade obtained	4.76	6.28	*
Fraction of female members in HH	0.62	0.47	*
Fraction of dependent members in HH	0.51	0.52	
Household size	4.39	6.38	*
Total livestock owned, tropical units	8.82	9.40	*
Fraction households own any oxen	0.37	0.61	*
Fraction of HHs that are members of an *iddir*	0.76	0.89	*
Network size	8.61	11.41	*
Fraction of HHs that have a bank account	0.05	0.06	
Number of sources from which a household can borrow	1.32	1.57	*

Source: Ethiopian Rural Household Survey (2011) and authors' computations.
Note: HH = household. *$p < .1$. **$p < .05$. ***$p < .01$.

Table 3.2 indicates that male-headed households hold more land (have larger plot sizes), of which a larger proportion is cultivable, compared to female-headed households. Wealthier households may have more land in total and also the capacity to invest in maintaining soil fertility by leaving larger areas (but not proportions) fallow. Women in male-headed households operate only 1 percent of the land, but the converse cannot be said for female-headed households, where men operate almost one-fifth of land area.[5] This may occur due to cultural norms that prohibit women from plowing land because it is perceived to be too strenuous (Frank 1999). Male-headed households are also more likely to have a larger fraction of their land registered, although the difference in magnitude is small—within our sample, land registration is almost universal.

Table 3.2 Characteristics of land owned and cropped by female- and male-headed households

Characteristic	Female-headed household	Male-headed household	*p* value
Total plot area, hectares	1.60	2.00	**
Total cropped area, hectares	1.19	1.69	*
Fraction of total land that is cropped	0.71	0.85	*
Fraction of cropped land that is good or medium quality	0.83	0.89	*
Fraction of total land that is good or medium quality	0.83	0.88	*
Fraction of cropped area operated by women	0.82	0.01	*
Fraction of plot area operated by women	0.84	0.01	*
Fraction of cropped area registered	0.95	0.97	**
Fraction of total land area registered	0.96	0.97	***

Source: Ethiopian Rural Household Survey (2011) and authors' computations.
Note: *$p < .1$. **$p < .05$. ***$p < .01$.

[5] Some of this may be driven by respondent bias since the agriculture module of our survey was administered to the household head.

Male-headed households were much more likely to have heard of the land registration process. Almost all male-headed households (90 percent) had heard of the process, compared to about three-quarters of female-headed households, albeit with some regional variation (see Kumar and Quisumbing 2012b for details). Throughout the 15 survey villages, male-headed households were more aware of public information meetings held before the land registration process, more likely to have attended such meetings (as well as a greater number of meetings), and more likely to have received some written material about the program.

Most households acknowledged that their plot boundaries were well demarcated before the land registration process started, and about a quarter to a third of the households reported facing land disputes before the registration process. They perceive the land title as a protection against encroachment and agree that the number of land disputes decreased after the land registration process was complete. All households, regardless of the sex of the household head, believe that the title increases their incentive for planting trees (more so for male-headed households) and increases the probability of receiving compensation in case of appropriation. Both male and female household heads also believe that having a land certificate improves the position of women.

Gender Differences in Knowledge about Land Rights

Because differences may exist between awareness of the land certification and knowledge about the specific bundle of rights created through the process, a 10-point quiz was administered separately to men and women in 2009, designed to elicit their knowledge of their land rights in three main domains: (1) land tenure security, (2) land transfer rights, and (3) gender and inheritance rights. For comparability with earlier work, the quiz was identical to that administered by Deininger, Ali, Holden, et al. (2008) , but it was administered not only to the head of the household but to a man and a woman within the household (usually the household head and spouse, but the respondent could also be another adult, for example, an adult son in a female-headed household). Rather than take the maximum score of the male and female respondents—which assumes that knowledge is shared within the household—we analyze male and female responses separately. As noted earlier, because of regional differences in the land certification provisions, the correct answers differ across the regions.

Table 3.3, which shows the components of each of the three domains, also reveals some unevenness in knowledge within each domain. For example, nearly everyone (97 percent of males and 98 percent of females) knew that boundary disputes could be resolved by the *tabia* land use committee, but few (8 percent of men and 2 percent of women) knew the maximum number of years that a household could lease out its land. There are also significant differences in the percentage of men and women with correct responses, with men almost always having a significantly higher proportion of correct answers.

Table 3.3 Male and female knowledge of land rights after land registration, 2009

Land right	Percentage reporting the correct answer		
	Men	Women	*p* value
Tenure security			
Recourse for boundary disputes	97	98	***
Tenure security if entire household migrates	15	15	
Ability to mortgage land	50	45	*
Tenure security if head of household migrates	68	65	***
Land transfer rights			
Maximum number of years household can lease use rights to others using modern technology	8	2	*
Maximum duration of rental contracts without registration	15	19	
Ability to increase rent in an existing contract	70	62	*
Gender and family law			
Division of land in case of divorce	84	83	
Ability to bequeath land to others who are not direct or adopted children	50	45	**
Share of property going to deceased spouse	9	9	

Source: Ethiopian Rural Household Survey (2011) and authors' computations.
Note: *$p < .1$. **$p < .05$. ***$p < .01$.

Table 3.4 shows alternative ways of aggregating the quiz results. The "land rights score" is a simple sum of correct answers to all 10 questions, reported separately for male and female respondents, with a maximum value of 10. The tenure security score, transferability score, and gender and family law score are percentages of correct answers in each set of questions. We use percentage of correct answers rather than raw scores because the number of items in each domain is not equal (there are four tenure security questions, while the two other domains have three questions each). In general, men outscored women, although the difference was not statistically significant for the full sample. However, regional differences are apparent: in Tigray, men's scores, though larger in all areas but the family law score, were not significantly different from women's scores, whereas in Amhara, men consistently and significantly outscored women. The only significant difference in Oromiya was with respect to the gender score, where women weakly did better than men; in SNNPR there were significant differences in the overall score and in the land transfer and gender scores, all in favor of men.

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Table 3.4 Distribution of men's and women's land rights knowledge scores, by region

Region	Number of observations	Land rights knowledge score (0–10)			Tenure security score (0–100)			Transferability score (0–100)			Gender and family law score (0–100)		
		Men	Women	*p* value	Men	Women	*p* value	Men	Women	*p* value	Men	Women	*p* value
Tigray	65	4.14	4.34		58.08	63.46		25.13	21.54		35.38	38.46	
Amhara	254	5.04	4.43	***	53.05	48.52	***	34.25	26.12	***	62.86	56.96	***
Oromiya	250	4.44	4.50		59.20	58.30		28.93	29.47		40.13	42.93	*
SNNPR	257	4.35	4.14	**	57.88	56.62		29.83	26.98	*	38.13	35.41	*
All	826	4.57	4.35	***	56.81	55.18	**	30.55	27.04	***	46.13	44.55	*

Source: Ethiopian Rural Household Survey (2011) and authors' computations.

Notes: SNNPR = Southern Nations, Nationalities, and People's Region. Scores reported for households in which both a male and female respondent answered the land rights quiz. *$p < .1$. **$p < .05$. ***$p < .01$ (based on unpaired *t*-tests, equal variances not assumed).

Gender Differences in Soil Conservation and Tree Planting

We now investigate whether differences between men and women in resource control and knowledge scores lead to significant differences in the adoption of soil conservation technologies and tree planting. We use two alternative gender indicators—sex of the household head and sex of the plot manager—and examine a range of SCTs: bunds, contours, and legumes. With regard to tree planting, we focus on trees in general and also eucalyptus, which was formerly promoted but now has been criticized because of its competition with other crops for moisture (Jagger and Pender 2003). We also present findings on coffee, a tree crop that is also a major cash crop, to highlight differences between male and female adoption of tree species.

The soil conservation measures we analyze are (1) construction of soil or stone bunds, (2) contouring, and (3) intercropping with legumes. Soil and stone bunds are structures built to control runoff, increasing soil moisture and reducing soil erosion (Kato et al. 2011). Because it is costly to protect large areas of land with bunds and difficult to construct continuous bunds, alternative methods of erosion control include grass strips with contour leveling, sometimes with trees or hedgerows. In our analysis we aggregate soil and stone bunds and combine grass strips with contouring. Intercropping involves planting nitrogen-fixing trees that can tolerate continuous and heavy pruning in a regular pattern with annual crops (Sinja, Kiptot, and Place 2012). We adopt a more liberal definition of intercropping with legumes by including all types of legumes, not just leguminous trees, in creating this variable. Interesting to note, although planting legumes enables farmers to reap the benefits of nitrogen fixation, this is not commonly viewed as a soil conservation technology in Ethiopia.

We also examine permanent investments in the form of tree planting and conduct the analysis at the household and plot level. Our measures of tree planting are a dichotomous variable indicating tree planting in the past five years and the number of trees planted per hectare (all trees, coffee trees, and eucalyptus). Using either definition, it appears that while differences exist, they are not overwhelmingly significant (Table 3.5). In the entire sample, on average, there are no significant differences in the adoption of SCTs, the probability of tree planting in the past five years, or the number of trees planted per hectare. There are a few regional differences, with female-headed households more likely to plant legumes and male-headed households having higher tree-planting densities in SSNPR. Male-headed households are also more likely to plant more coffee trees per hectare in SNNPR. In Oromiya, female-headed households planted more trees per hectare (eucalyptus trees in particular).

Although a higher percentage of plots managed by women had trees on average, this was driven largely by Oromiya; in Tigray, while a higher percentage of male-managed plots had trees than female-managed plots, the magnitudes are very low. On average, a higher proportion of female-managed plots has eucalyptus, while a higher proportion of male-managed plots has coffee, with these differences being significant in Amhara and SNNPR. This may be associated with eucalyptus trees' being used for fuel, collecting wood for fuel being a woman's task, and the tendency of men to be more involved in cash crop production. There are no significant differences in the proportion of male- and female-managed plots with legumes. However, these mean comparisons do not control for other household and individual characteristics that may affect adoption of SCTs and tree planting, notably whether the plot is registered, the degree of transferability of the plot, and men's and women's knowledge of their land rights.

Table 3.5 Gender differences in soil conservation and tree planting, household and plot level

	Tigray			Amhara			Oromiya			SNNPR			Full sample		
Panel A. Household-level differences by sex of household head															
Technique	**MHH**	**FHH**	**Sig.**	**MHH**	**FHH**	**Sig.**	**MHH**	**FHH**	**Sig.**	**MHH**	**FHH**	**Sig.**	**MHH**	**FHH**	**Sig.**
Bunds	0.89	0.77		0.77	0.64		0.44	0.57		0.20	0.11		0.49	0.46	
Contours	0.00	0.00		0.18	0.21		0.15	0.20		0.04	0.09		0.12	0.14	
Legumes	0.00	0.00		0.00	0.00		0.05	0.10		0.00	0.03	**	0.02	0.04	
Planted trees in past five years	0.49	0.38		0.54	0.67		0.66	0.56		0.86	0.91		0.68	0.68	
Number of trees planted per hectare	0.65	0.47		0.23	0.20		0.58	1.55	***	1.45	0.83	***	0.79	0.87	
Number of coffee trees planted per hectare	0.00	0.00		0.01	0.00	*	0.12	0.40		0.71	0.34	***	0.27	0.24	
Number of eucalyptus trees planted per hectare	0.51	0.47		0.15	0.18		0.17	0.32	*	0.41	0.35		0.27	0.32	
Panel B. Plot-level differences by sex of plot manager															
Difference	**Male**	**Female**		**Male**	**Female**		**Male**	**Female**		**Male**	**Female**		**Male**	**Female**	
Whether grow trees on plot	0.03	0.00	***	0.10	0.09		0.20	0.33	**	0.45	0.38		0.22	0.23	*
Whether grow eucalyptus on plot	0.01	0.00		0.07	0.09		0.08	0.13		0.15	0.17		0.09	0.12	**
Whether grow coffee on plot	0.00	0.00		0.01	0.00	***	0.07	0.05		0.29	0.18	***	0.10	0.07	**
Whether grow legumes on plot	0.20	0.20		0.17	0.17		0.10	0.08		0.09	0.12		0.12	0.14	

Source: Ethiopian Rural Household Survey (2011) and authors' computations.

Notes: SNNPR = Southern Nations, Nationalities, and People's Region**;** MHH = male-headed household; FHH = female-headed household; Sig. = significance. **p* < .1. ***p* < .05. ****p* < .01 (based on unpaired *t*-tests, not assuming equal variances).

4. REGRESSION RESULTS

Determinants of Knowledge Scores

Because men's and women's knowledge of their property rights is not truly exogenous, we analyze the factors that contribute to their knowledge of property rights. Table 4.1 examines the determinants of household, men's, and women's land rights knowledge scores, as a function of household human capital characteristics, land and assets of the household, and assets at marriage and family background of the husband and wife. We define the household land rights knowledge score as the simple sum of the male's and female's correct answers to all 10 questions in the quiz, with a maximum value of 20, whereas the men's and women's land rights scores are the number of the male and female respondents' correct answers, respectively, with a maximum value of 10. These regressions control for peasant association (PA) fixed effects to control for other unobservable characteristics at the PA level. In addition to individual and household attributes such as education and initial wealth, we will examine the role of female members in the LACs as a possible mechanism for increasing women's knowledge of their land rights. Kumar and Quisumbing (2012b) found that the presence of female members in the LAC encourages participation by female-headed households and does not discourage participation by male-headed households. Does this impact of female membership in the LACs extend to legal knowledge?

Table 4.1 Determinants of land rights scores, ordered probit estimates

Characteristic	Household land rights score	Men's land rights score	Women's land rights score
Household characteristic			
Age of head	0.025	0.026	0.007
	(0.015)	(0.020)	(0.021)
Age of head, squared	–0.000*	–0.000	–0.000
	(0.000)	(0.000)	(0.000)
Female-headed household	–0.273	–0.002	–0.454**
	(0.266)	(0.289)	(0.185)
Schooling of head	0.051**	0.041**	0.021
	(0.020)	(0.021)	(0.020)
Highest grade of female in household	–0.027**		–0.024**
	(0.012)		(0.010)
Highest grade of male in household	–0.010	–0.009	
	(0.012)	(0.011)	
Land and assets of household			
Land area, 2004	0.057	0.104**	–0.016
	(0.035)	(0.042)	(0.029)
Percentage of good land	–0.083	–0.261	0.126
	(0.160)	(0.166)	(0.215)
Percentage of area registered	–0.324	–0.148	–0.483
	(0.304)	(0.321)	(0.437)
Percentage of area cultivated by women	–0.344	–0.058	–0.397
	(0.309)	(0.260)	(0.362)
Livestock units, 2004	0.031***	0.010	0.041***
	(0.011)	(0.012)	(0.016)
Lowest land quartile in PA	0.004	–0.000	0.008
	(0.171)	(0.130)	(0.197)

Table 4.1 Continued

Characteristic	Household land rights score	Men's land rights score	Women's land rights score
Second land quartile in PA	–0.024	–0.025	0.017
	(0.145)	(0.186)	(0.120)
Third land quartile in PA	–0.076	–0.010	–0.070
	(0.103)	(0.131)	(0.093)
Land administration			
Any women in land administration committee	–0.726***	–0.703***	–0.106
	(0.218)	(0.267)	(0.110)
Information on union from 1997 round			
Male's number of unions	–0.043	–0.014	
	(0.047)	(0.034)	
Female's number of unions	0.144*		0.086
	(0.082)		(0.078)
Area of land owned at marriage (husband)			
	–0.092***	–0.058**	
	(0.028)	(0.025)	
Value of livestock owned at marriage (husband)	0.000	0.000	
	(0.000)	(0.000)	
Father's land (husband)	0.003***	0.002***	
	(0.001)	(0.001)	
Father's education (husband)	–0.349**	–0.270*	
	(0.177)	(0.159)	
Area of land at marriage (wife)	0.628***		0.441***
	(0.187)		(0.131)
Value of livestock owned at marriage (wife)	0.000		–0.000
	(0.000)		(0.000)
Father's land (wife)	0.000		0.007
	(0.007)		(0.011)
Father's education (wife)	0.118		0.054
	(0.145)		(0.194)
Number of observations	661	665	661

Source: Ethiopian Rural Household Survey (2011) and authors' computations.
Note: PA = peasant association. Robust standard errors are in parentheses. All regressions include PA fixed effects not reported here. *$p < .1$. **$p < .05$. ***$p < .01$.

At the household level, the overall land rights knowledge score is positively associated with the schooling of the household head and livestock ownership but negatively associated with the highest grade attained by a female household member and whether women were on the local LAC. Interesting to note, the family background of the husband and wife appears to have a countervailing effect: a larger area of land owned by the husband at marriage has a negative effect on the household knowledge score, but a larger area owned by the wife increases the household knowledge score. Husbands whose fathers had more land, but fewer years of schooling, contributed to higher household knowledge scores—this may reflect some intergenerational specialization in farming, with fathers who were farmers possibly tending to be less educated. Men's land rights knowledge scores tend to follow the pattern of the household score. Women's land rights knowledge scores were lower if they belonged to a female-headed household, and

their scores did not improve if other women within the household were better educated. However, women who owned more land at the time of marriage had better overall scores.

Table 4.2 examines the possible determinants of the gender gap in land rights scores, defined as the simple difference between men's and women's topic-specific scores. If the gender gap is greater than zero (positive) for a particular household, this implies that the male respondent has a higher proportion of correct answers in a specific land rights domain than does the female respondent. Conversely, if the gender gap is less than zero, the female respondent has a higher proportion of correct answers in that domain. Gender gaps are computed separately for each of the three land rights domains—tenure security, transferability, and gender and inheritance rights. Gender gaps in the tenure security score were lower for households in the lowest land quartile. Interesting to note, the gender gap in the land transfer score was higher in households with larger land areas and a larger proportion of area cultivated by women. Smaller gender gaps in the transferability score were found in households with more livestock and households with a larger difference between the husband's and wife's landholdings, although all these relationships were only weakly significant. Gender gaps in knowledge about gender-related rights in inheritance were significantly higher in female-headed households and households with more educated heads. A striking result is that the presence of women in the LAC was associated with a smaller gender gap in knowledge scores across all three domains of land rights.

Table 4.2 Determinants of gap between men's and women's land rights scores, ordinary least squares estimates

	Difference in men's and women's		
Characteristic	**Tenure security score**	**Land transfer score**	**Gender rights score**
Household characteristic			
Age of head	0.147	1.283**	1.006
	(0.360)	(0.574)	(0.811)
Age of head, squared	–0.000	–0.011**	–0.008
	(0.003)	(0.005)	(0.007)
Female-headed household	3.314	2.807	14.202**
	(3.822)	(4.754)	(6.339)
Schooling of head	0.362	0.081	1.729**
	(0.382)	(0.346)	(0.814)
Difference between highest grade of male and female in household	0.163	0.393	–0.426*
	(0.185)	(0.232)	(0.242)
Land and assets of household			
Land area, 2004	1.320	2.334*	1.229
	(1.190)	(1.181)	(0.937)
Percentage of good land	–7.035	–0.756	–8.674
	(5.050)	(4.840)	(6.789)
Percentage of area registered	3.629	9.728	9.168
	(6.833)	(11.961)	(10.604)
Percentage of area cultivated by women	1.995	11.032*	–6.542
	(6.172)	(5.899)	(10.312)
Livestock units, 2004	0.201	–1.095*	–0.468
	(0.513)	(0.535)	(0.500)
Lowest land quartile in PA	3.673*	–3.161	1.165
	(1.996)	(4.814)	(5.673)

Table 4.2 Continued

Characteristic	Difference in men's and women's Tenure security score	Land transfer score	Gender rights score
Second land quartile in PA	4.260	–2.766	–0.855
	(2.793)	(2.880)	(2.959)
Third land quartile in PA	4.268	–2.997	1.148
	(2.636)	(3.135)	(3.015)
Land administration			
Any women in land administration committee	–11.433**	–10.760*	–22.312***
	(4.296)	(5.247)	(4.815)
Male-female differences in 1997			
Number of unions	–0.662	1.568	–2.457
	(1.251)	(0.988)	(1.457)
Land owned at marriage	0.692	–0.810	–0.509
	(0.870)	(0.554)	(0.694)
Livestock at marriage	0.000	–0.000	–0.000
	(0.000)	(0.000)	(0.000)
Father's land	–0.001	0.039*	0.038
	(0.029)	(0.019)	(0.024)
Father's education	–1.722	4.277	3.783
	(1.835)	(4.180)	(5.079)
Constant	–10.389	–33.745*	–11.922
	(11.381)	(16.624)	(23.784)
Observations	661	661	661
R-squared	.073	.108	.286

Source: Ethiopian Rural Household Survey (2011) and authors' computations.
Note: PA = peasant association. Robust standard errors are in parentheses. All regressions include PA fixed effects not reported here. *$p < .1$. **$p < .05$. ***$p < .01$.

Determinants of Soil Conservation Practices at the Household Level

Table 4.3 presents probit regressions on the probability of (1) practicing any SCTs in 2009, (2) having soil or stone bunds in 2009, and (3) practicing contour farming in 2009 as a function of household characteristics, household land and asset (livestock) holdings, various indicators of land rights knowledge, and the interaction between land and asset holdings and knowledge scores, with the dummy variable indicating a female-headed household. We also estimate these regressions with PA fixed effects to control for unobserved PA-level characteristics.

Table 4.3 Household-level conservation practices in 2009, with interactions for FHHs, probit estimates (marginal effects reported)

	Levels			Fixed effects		
Characteristic	**Practice soil conservation**	**Have soil or stone bunds**	**Practice contour farming**	**Practice soil conservation**	**Have soil or stone bunds**	**Practice contour farming**
Household characteristic						
FHH	–0.215	–0.481***	0.111	–0.381	–0.566***	0.186
	(0.263)	(0.151)	(0.225)	(0.361)	(0.144)	(0.283)
Schooling of head	–0.023**	–0.018*	–0.008*	–0.001	0.012	–0.007***
	(0.010)	(0.009)	(0.004)	(0.011)	(0.013)	(0.003)
Household size, 2009	0.030**	0.011	0.017**	0.034*	0.025	0.010**
	(0.013)	(0.015)	(0.007)	(0.019)	(0.016)	(0.004)
Household land and asset holdings						
Land area, 2004	–0.001	0.015	0.003	0.018	0.028	0.000
	(0.024)	(0.025)	(0.010)	(0.025)	(0.027)	(0.007)
Percentage of good land	–0.389***	–0.334***	–0.060	–0.077	–0.113	–0.086**
	(0.122)	(0.099)	(0.061)	(0.092)	(0.085)	(0.034)
Percentage of area registered	0.035	–0.097	–0.051	0.146	–0.086	–0.061
	(0.167)	(0.198)	(0.132)	(0.183)	(0.229)	(0.085)
Percentage of area cultivated by women	0.086	0.216**	0.008	0.095	0.258*	–0.001
	(0.100)	(0.101)	(0.047)	(0.098)	(0.133)	(0.032)
Whether PA is in low rainfall area	0.362***	0.347***	0.034	n.a.	n.a.	n.a.
	(0.116)	(0.127)	(0.037)			
Livestock units, 2004	0.008	0.006	0.007**	0.004	–0.003	0.006*
	(0.011)	(0.010)	(0.003)	(0.010)	(0.009)	(0.003)
Land rights knowledge						
Household land rights score	–0.001	0.006	0.005	–0.005	0.008	0.001
	(0.014)	(0.014)	(0.006)	(0.013)	(0.015)	(0.004)
Gap in tenure score	–0.001	–0.001	–0.001**	–0.001	–0.001	–0.001**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)
Gap in transfer score	0.000	0.000	–0.000	–0.001*	–0.002**	–0.000
	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)	(0.000)
Gap in gender score	0.001	0.001	–0.000	–0.000	–0.000	–0.000
	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)	(0.000)

Table 4.3 Continued

Characteristic	Levels			Fixed effects		
	Practice soil conservation	Have soil or stone bunds	Practice contour farming	Practice soil conservation	Have soil or stone bunds	Practice contour farming
Interaction with FHH						
Land × FHH	0.128**	0.174**	0.004	0.102**	0.139*	–0.005
	(0.056)	(0.077)	(0.030)	(0.047)	(0.071)	(0.020)
Livestock × FHH	–0.034*	–0.035*	–0.010	–0.019	–0.014	–0.006
	(0.018)	(0.019)	(0.008)	(0.018)	(0.022)	(0.005)
Household Score × FHH	0.014	0.019	–0.005	0.027	0.027	–0.005
	(0.033)	(0.033)	(0.017)	(0.041)	(0.041)	(0.011)
Gap in Tenure Score × FHH	–0.007**	–0.008***	–0.001	–0.007**	–0.009***	–0.001
	(0.003)	(0.003)	(0.002)	(0.003)	(0.003)	(0.001)
Gap in Transfer Score × FHH	0.001	0.001	0.000	0.003	0.004	–0.000
	(0.003)	(0.003)	(0.002)	(0.003)	(0.003)	(0.001)
Gap in Gender Score × FHH	0.007***	0.007***	0.004*	0.009***	0.011***	0.002
	(0.002)	(0.003)	(0.002)	(0.003)	(0.004)	(0.001)
Observations	700	700	700	661	691	661

Source: Ethiopian Rural Household Survey (2011) and authors' computations.

Note: FHH = female-headed household; PA = peasant association; n.a. = not applicable because variable is not included in fixed effects estimate]. Robust standard errors are in parentheses. Regressions included controls for age and age squared of household head, age and sex composition of the household, and position in PA land distribution. PA fixed effects are not reported. *$p < .1$. **$p < .05$. ***$p < .01$.

We use the household knowledge score (or the household land rights score) and the gender gap in the three domains of tenure security, transferability, and gender and inheritance rights as our indicators of legal rights knowledge. The household score proxies the household's general level of knowledge, while the gender gaps in component indicators indicate gender gaps in knowledge of particular areas.

Practicing soil conservation requires labor—larger households are more likely to practice any SCT. Families living in areas with low rainfall (defined as annual rainfall less than 1,010 millimeters) and those with less land of good quality are more likely to practice SCT. Possibly because SCTs require substantial labor input, practicing SCTs is negatively correlated with the head's educational attainment. To investigate whether resources have different impacts depending on the sex of the household head, we interacted key variables with the female-headed household dummy. We find that female-headed households with larger land areas are more likely to adopt SCTs, while female-headed households with larger livestock holdings are less likely to adopt SCTs, possibly because of the time required for livestock rearing, which is typically a woman's responsibility in Ethiopia.

It is worth noting that the overall household land rights score does not have a significant effect on adoption of any SCT but that gender gaps in knowledge about land rights diminish the adoption of specific SCTs (to be discussed below). This result is robust to the inclusion of fixed effects. Notably, gender gaps in the tenure score diminish adoption of SCTs by female-headed households, but larger gaps in the gender rights score—that is, a higher men's score relative to women's score—are associated with higher adoption by female-headed households.

While the sex of the household head does not have a significant effect on the probability of SCT adoption in general, female-headed households were significantly less likely to have soil or stone bunds in 2009, although the fraction of area cultivated by women is weakly associated with a higher probability of having bunds. Households with better-educated heads are also weakly less likely to have bunds. Biophysical and agroecological characteristics clearly matter: households in low rainfall areas are more likely to have bunds, and households with a greater proportion of poor-quality land are more likely to have bunds. In the specification with fixed effects, households with larger gender gaps in transfer scores are less likely to have bunds. Some interactions with the female-headed household dummy are similar to the results for SCT adoption in general: a higher men's gender score is associated with having soil or stone bunds, female-headed households with more land are more likely to have bunds, but those with more livestock are less likely to have them. Within female-headed households, gender gaps in tenure security and gender rights scores have opposite effects: higher gaps in the tenure security score decrease the probability of having bunds, while higher gaps in the gender score increase the probability of having bunds. It is not clear what is driving these results. However, some issues relating to gender of the plot manager and his or her knowledge will become clearer in later sections that report results at the plot level.

Reflecting the labor requirements needed for contouring as well as the opportunity costs of labor, larger households are more likely to take up contour farming, but households with better-educated household heads are less likely to do so. In the fixed effects specification, households with a higher proportion of good land are less likely to practice contour farming, but households with more livestock are also more likely to practice this type of SCT. Gender gaps in the tenure security score are likely to diminish adoption of contouring.

Some key findings emerge from this analysis. First, adoption of SCTs is a labor-intensive process that tends to be higher in households with more labor resources (household size) but can be lower in households with higher opportunity costs of labor (better-educated households, more livestock). Second, biophysical properties of the farm clearly matter, with some types of technologies being more suitable to low rainfall areas (bunds). Third, gender gaps in knowledge of land rights has negative impacts on the adoption of some SCTs, whereas the general knowledge level of the household does not. Last, in no case was the fraction of land registered an important determinant of the adoption of SCTs. This might be because of the high rate of land registration—close to universal. This finding, together with that on the negative impact of gender gaps in knowledge about SCT adoption, suggests that the gender gap in land rights knowledge needs to be addressed to increase adoption of SCTs.

Determinants of Tree Planting at the Household Level

Tree planting is a visible long-term investment in land. Table 4.4 presents an analysis of the probability of tree planting as well as the number of trees planted per hectare in the past five years. Female-headed households are significantly less likely to have planted trees in the past five years. However, female-headed households that have better knowledge of land rights are more likely to have planted trees in the past five years. Education of the household head has a weakly significant positive effect on tree planting but a strong positive effect on the number of trees per hectare (the significance of this estimate weakens once village-level unobservables are considered). The household land rights score has a negative impact on tree planting, but gender gaps in the transfer score are likewise associated with lower probabilities of tree planting. This implies that gender gaps in knowledge about transferability diminish incentives to plant trees because transferability would imply that investments can be recouped when land is transferred or sold. However, when interactions with female headship are considered, we see that higher knowledge scores do induce female-headed households to plant trees. Such results at the household level, however, mask differences in plot management that are revealed when we undertake analyses at the plot level separately for male and female plot managers.

Table 4.4 Tree planting at the household level in the past five years, with interactions for FHHs

	Levels		Fixed effects	
Characteristic	**Whether planted trees (probit)**	**Number of trees planted per hectare (OLS)**	**Whether planted trees (probit)**	**Number of trees planted per hectare (OLS)**
Household characteristic				
FHH	–0.634***	–0.340	–0.657***	–0.165
	(0.181)	(0.380)	(0.183)	(0.310)
Schooling of head	0.019*	0.058***	0.001	0.030*
	(0.011)	(0.015)	(0.009)	(0.016)
Household size, 2009	0.008	0.016	0.004	–0.019
	(0.014)	(0.029)	(0.014)	(0.031)
Household land and asset holdings				
Land area, 2004	–0.013	–0.040	–0.018	0.013
	(0.026)	(0.065)	(0.016)	(0.061)
Percentage of good land	0.146	–0.036	0.033	–0.078
	(0.097)	(0.273)	(0.101)	(0.319)
Percentage of area registered	0.090	0.076	0.067	0.077
	(0.152)	(0.304)	(0.172)	(0.166)
Percentage of area cultivated by women	0.088	0.238	0.082	0.285
	(0.106)	(0.143)	(0.123)	(0.171)
Whether PA is in low-rainfall area	–0.081	–0.448	n.a.	n.a.
	(0.118)	(0.260)		
Livestock units, 2004	–0.002	–0.033	0.002	0.022
	(0.012)	(0.025)	(0.009)	(0.014)
Land rights knowledge				
Household land rights score	–0.017*	–0.066***	–0.005	–0.021
	(0.009)	(0.016)	(0.012)	(0.018)
Gap in tenure score	–0.000	0.004	–0.000	0.004
	(0.001)	(0.003)	(0.001)	(0.003)
Gap in transfer score	–0.002**	–0.002	–0.001	0.000
	(0.001)	(0.002)	(0.001)	(0.001)
Gap in gender score	–0.001	–0.003	0.000	–0.001
	(0.001)	(0.002)	(0.001)	(0.002)

Table 4.4 Continued

Characteristic	Levels		Fixed effects	
	Whether planted trees (probit)	Number of trees planted per hectare (OLS)	Whether planted trees (probit)	Number of trees planted per hectare (OLS)
Interactions with FHH				
Land × FHH	0.014	0.056	0.018	0.075
	(0.046)	(0.087)	(0.045)	(0.057)
Livestock × FHH	0.008	0.019	0.007	–0.015
	(0.018)	(0.034)	(0.017)	(0.022)
Household Score × FHH	0.071**	0.003	0.071***	–0.007
	(0.027)	(0.045)	(0.026)	(0.037)
Gap in Tenure Score × FHH	0.003	0.003	–0.000	0.001
	(0.005)	(0.007)	(0.006)	(0.007)
Gap in Transfer Score × FHH	0.003	0.001	0.001	–0.002
	(0.003)	(0.005)	(0.003)	(0.004)
Gap in Gender Score × FHH	–0.000	–0.003	–0.001	–0.004
	(0.003)	(0.006)	(0.003)	(0.005)
Observations	549	549	509	549
R-squared		.217		.380

Source: Ethiopian Rural Household Survey (2011) and authors' computations.

Note: OLS = ordinary least squares; FHH = female-headed household; PA = peasant association; n.a. = not applicable because variable is not included in fixed effects estimates. Robust standard errors are in parentheses. Regressions included controls for age and age squared of household head, age and sex composition of the household, and position in PA land distribution. Marginal effects are reported for probit regressions. PA fixed effects are not reported. *$p < .1$. **$p < .05$. ***$p < .01$.

Determinants of Tree Planting and Soil Conservation Practices at the Plot Level

Tables 4.5 and 4.6 present regressions on the determinants of tree planting and soil conservation practices at the plot level separately for male- and female-managed plots. This information was taken from the agriculture module, which collects information about the types of crops grown (up to four on the same plot, allowing for intercropping). While we know whether trees are grown and whether specific types of trees are grown, we have information about only the planting of legumes, not other soil conservation practices. Most plots in Ethiopian farms are male managed—as indicated by the large number of observations (more than 3,600) compared to female-managed plots (only 284). Our sample sizes are also small (in general) because we are examining households where we have both male and female knowledge scores.

Similar to the household-level results, on male-managed plots, higher schooling attainment of the plot manager is positively associated with planting coffee, although this result is not robust to the inclusion of fixed effects (Table 4.5). Tree planting does not appear to have high labor requirements—household size has no impact—but tree planting decreases with plot size, possibly because it is harder to plant a larger area intensively with trees. Legumes appear to require more labor—they are less likely to be grown on male-managed plots in smaller households, possibly because they are considered a "female" crop, unless they are marketed, and they also tend to be grown on larger plots in low rainfall areas. Plots with good soil are associated with both tree planting and planting of legumes, although it is possible that there is some endogeneity (plots where legumes have been planted could be more fertile). It is interesting that whether the plot is registered weakly increases the probability of planting legumes, whereas whether the plot can be transferred to others is associated with higher probabilities of tree planting (in general, as well as coffee and eucalyptus in particular); this is consistent with our expectations of the impact of

transferability on land-related investments. The household land rights score does not significantly affect planting of trees or legumes, but there are some significant impacts of gender gaps in component scores, although they are small in magnitude. A higher gender gap in the tenure security score is associated with higher probabilities of planting coffee, but gaps in the land transfer score reduce probabilities of planting trees, in general. This shows that in households where the men's transfer score is higher than the women's, trees are less likely to be grown on plots men manage.

Fewer variables are significant in the women's plot regressions (Table 4.6), possibly because of lack of power owing to smaller sample sizes. It is noteworthy, however, that whether the (female) plot manager is the household head turns up significant in these regressions, whereas it was insignificant in all of the male plot regressions. It is possible that a male plot manager has decisionmaking rights on plots that he manages, whereas a woman is able to exercise her decisionmaking rights only when she is a household head—that is, a female plot manager who is not the head of the household still has limited decisionmaking power. Whether a woman is the head of the household also increases the likelihood that she plants trees (specifically eucalyptus) and legumes but reduces the probability of her planting coffee. It is possible that women are less interested in planting an export crop with a longer gestation period, whereas eucalyptus and legumes are more closely related to women's traditional tasks of firewood and food provision.

Impacts of household size are weak in the levels results but appear significant and negative in the regressions for coffee and legumes once fixed effects are included. Some biophysical characteristics of the plot are also important, with trees more likely to be planted on gently or steeply sloped plots (trees, eucalyptus, or legumes in the fixed effects estimates), legumes on plots with good soil (although potential endogeneity should also be noted), and coffee and legumes on irrigated plots in the fixed effects estimates. Transferability of the plot is associated with a higher probability of planting trees and lower probability of planting legumes. Reflecting near universal registration, whether the plot is registered affects neither tree planting nor the probability of planting legumes. Gender gaps in the tenure security score appear to increase probabilities of tree planting and of planting eucalyptus, but gaps in the gender score reduce the probability of planting both trees in general and eucalyptus. These results are interesting as they show how men's knowledge of different domains of land rights affects women within their households. For example, in households where the men's tenure score is greater than the women's score, trees are more likely to be planted on female-managed plots. It is possible that men use their superior knowledge of land rights to induce women to plant trees. However, when men are more aware of gender and inheritance rights than women, the effect is reversed—trees are less likely to be planted on female-managed plots. This might be because women plot managers who know less about their inheritance rights do not perceive that they have the ability to reap the benefits of a long-term investment in land, and the men who do know about these rights do not share this knowledge. Many of the coefficients of gender gaps in land rights scores are either insignificant or very small in magnitude once fixed effects are included. The results for coffee, in particular, should be taken with caution given the small sample size.

Table 4.5 Soil conservation practices at the plot level, male-managed plots: Probit estimates, marginal effects reported

Characteristic	Whether crop grown (levels)				Whether crop grown (fixed effects)			
	Trees	Coffee	Eucalyptus	Legumes	Trees	Coffee	Eucalyptus	Legumes
Whether manager is head of household	0.030	–0.002	0.014	–0.051	0.017	–0.036	0.009	–0.004
	(0.029)	(0.005)	(0.012)	(0.034)	(0.028)	(0.043)	(0.011)	(0.017)
Education of manager	0.004	0.001**	0.000	–0.006*	0.001	–0.004***	0.000	–0.003
	(0.004)	(0.000)	(0.002)	(0.003)	(0.003)	(0.001)	(0.001)	(0.003)
Household size, 2009	0.010	0.001	0.001	–0.014*	0.001	–0.004	0.001	–0.007
	(0.011)	(0.002)	(0.005)	(0.007)	(0.008)	(0.004)	(0.003)	(0.005)
Plot size in hectares, 2009	–0.240***	–0.006	–0.186***	0.070***	–0.312***	–0.014	–0.162***	0.078***
	(0.076)	(0.010)	(0.047)	(0.027)	(0.097)	(0.033)	(0.016)	(0.021)
PA is in low-rainfall area	–0.123	–0.048***	–0.026	0.087**	n.a.	n.a.	n.a.	n.a.
	(0.084)	(0.017)	(0.024)	(0.039)				
Plot with good soil	0.092***	0.010*	0.006	0.040	0.013	0.029***	–0.017	0.049***
	(0.032)	(0.006)	(0.013)	(0.026)	(0.028)	(0.009)	(0.019)	(0.018)
Plot with gentle or steep slope	0.173***	0.013	0.048*	0.004	0.096**	–0.014	0.069***	0.025
	(0.061)	(0.009)	(0.028)	(0.025)	(0.045)	(0.024)	(0.021)	(0.021)
Percentage of plot irrigated	0.000	–0.000	0.000	–0.001	0.001*	0.001***	0.000	–0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Livestock units, 2009	–0.018*	–0.008**	0.001	0.001	–0.002	–0.009***	0.000	–0.001
	(0.011)	(0.003)	(0.002)	(0.003)	(0.002)	(0.003)	(0.001)	(0.002)
Plot is registered	0.052	0.007	0.003	0.046*	0.033	0.030	0.001	0.049**
	(0.035)	(0.005)	(0.012)	(0.028)	(0.028)	(0.022)	(0.010)	(0.020)
Plot can be transferred to others	0.076***	0.009***	0.026***	0.005	0.088***	0.038***	0.017**	–0.001
	(0.023)	(0.004)	(0.010)	(0.018)	(0.019)	(0.012)	(0.008)	(0.016)
Household land rights	–0.011	–0.001	0.002	0.000	0.001	0.002	0.002	–0.001
	(0.007)	(0.001)	(0.002)	(0.002)	(0.004)	(0.003)	(0.002)	(0.002)
Gap in tenure security	0.000	0.000	–0.000*	–0.000	0.001	0.000***	–0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Gap in land transfer score	–0.001*	–0.000*	–0.000	0.000	–0.000	–0.000	–0.000	–0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Gap in gender score	0.000	–0.000	–0.000	0.000	0.000	–0.000	–0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	3,645	3,645	3,645	3,645	3,308	1,893	3,204	3,578

Source: Ethiopian Rural Household Survey and authors' computations.

Note: n.a. = not applicable because variable not included in fixed effects estimate. Robust standard errors are in parentheses. Regressions included controls for age and age squared of household head, age and sex composition of the household, and position in Peasant association land distribution. Peasant association fixed effects are not reported.*$p < .1$. **$p < .05$. ***$p < .01$.

Table 4.6 Soil conservation practices at the plot level, female-managed plots: Probit estimates, marginal effects reported

	Whether crop grown (levels)				Whether crop grown (fixed effects)			
Characteristic	**Trees**	**Coffee**	**Eucalyptus**	**Legumes**	**Trees**	**Coffee**	**Eucalyptus**	**Legumes**
Whether manager is head of	0.063*	–0.521***	0.046**	0.085*	0.018	–1.000***	0.009	0.008
	(0.034)	(0.125)	(0.021)	(0.049)	(0.032)	(0.000)	(0.013)	(0.082)
Education of manager	–0.002	–0.000	0.021	–0.003	–0.018	–0.028**	–0.008	–0.006
	(0.030)	(0.000)	(0.014)	(0.038)	(0.029)	(0.012)	(0.013)	(0.074)
Household size, 2009	0.021*	–0.000	0.001	–0.010	–0.002	–0.006**	–0.007	–0.029**
	(0.011)	(0.000)	(0.005)	(0.007)	(0.010)	(0.002)	(0.004)	(0.013)
Plot size in hectares, 2009	–0.095	0.000	–0.156**	0.111	–0.093*	0.002	–0.093***	0.189*
	(0.087)	(0.000)	(0.063)	(0.078)	(0.055)	(0.001)	(0.036)	(0.110)
Peasant association is in low-	–0.052	–0.000	–0.000	0.055	n.a.	n.a.	n.a.	n.a.
	(0.077)	(0.000)	(0.027)	(0.037)				
Plot with good soil	0.040	0.000	0.001	0.103***	0.003	0.002**	0.007	0.120***
	(0.053)	(0.000)	(0.031)	(0.020)	(0.067)	(0.001)	(0.015)	(0.026)
Plot with gentle or steep	0.159**	–0.000	0.092	0.078	0.153*	–0.022***	0.125**	0.164**
	(0.080)	(0.000)	(0.071)	(0.051)	(0.082)	(0.008)	(0.064)	(0.079)
Percentage of plot irrigated	0.000	0.000	–0.000	0.000	–0.000	0.000**	–0.000	0.001**
	(0.001)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)
Livestock units, 2009	–0.019**	0.000	0.004	–0.006	–0.005	–0.003**	0.005*	–0.010
	(0.010)	(0.000)	(0.004)	(0.005)	(0.008)	(0.001)	(0.003)	(0.009)
Plot is registered	–0.138	–0.000	0.039	0.038	–0.145	–0.001	0.014	–0.081
	(0.158)	(0.000)	(0.026)	(0.049)	(0.213)	(0.003)	(0.011)	(0.135)
Plot can be transferred to	0.129***	0.000	0.022	–0.179**	0.021	0.014***	–0.041	–0.138*
	(0.036)	(0.000)	(0.036)	(0.088)	(0.046)	(0.005)	(0.041)	(0.074)
Household land rights score	0.013	0.000	0.009	–0.004	0.002	0.007**	–0.003*	–0.012
	(0.014)	(0.000)	(0.007)	(0.006)	(0.009)	(0.003)	(0.002)	(0.009)
Gap in tenure security score	0.002*	0.000	0.002***	0.000	–0.000	0.000**	–0.000	–0.001
	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)
Gap in land transfer score	0.001	–0.000	0.000	–0.000	0.001	0.000***	0.000	–0.000
	(0.001)	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)
Gap in gender score	–0.003***	0.000	–0.002***	–0.000	–0.001	–0.001***	–0.000*	0.001
	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)
Observations	284	152	284	284	266	91	266	252

Source: Ethiopian Rural Household Survey (2011) and authors' computations.

Note: n.a. = not applicable because variable not included in fixed effects estimate. Robust standard errors are in parentheses. Regressions included controls for age and age squared of household head, age and sex composition of the household, and position in peasant association land distribution. Peasant association fixed effects are not reported. *$p < .1$. **$p < .05$. ***$p < .01$.

5. CONCLUDING REMARKS AND POLICY IMPLICATIONS

This paper aimed to examine the medium-term impact of the land registration effort in Ethiopia six years after the initiation of the program. Although male-headed households have a higher proportion of land registered compared to female-headed households, the difference is small, reflecting the near-universal registration of land in our study area. However, the disparity in knowledge about land rights is more glaring. Controlling for the household level of land rights knowledge, we find that gender gaps in knowledge about land rights in three domains—tenure security, land transferability, and gender rights—diminish the adoption of soil conservation practices as well as the planting of tree crops and legumes, although different domains of rights matter for different practices. This suggests that closing the knowledge gap in legal rights is an important step to improving adoption of soil conservation technologies and sustainable farming techniques.

Legal literacy campaigns are therefore important to address low levels of land rights knowledge, in general, and gender gaps in knowledge, in particular. Our finding of the positive correlation between the household knowledge score and head's years of schooling and livestock ownership suggests that knowledge of land rights is higher for those households that have higher physical and human wealth. Men's land rights scores, in particular, are higher in households that own larger areas of land. However, having a woman in the LAC, while increasing women's knowledge of the land reform process and encouraging their attendance at meetings (and not affecting men's attendance; see Kumar and Quisumbing 2012b), is negatively associated with the men's knowledge score and with household-level knowledge scores. It is possible that females on an LAC are better able to teach women but not men: the reduction in the gender gap in scores when a woman is on the LAC might be because men have lower scores and women higher scores. Indeed, this effect is highest for the gender gap in gender and inheritance rights scores. This effect could also be related to the tendency for women to be on the LAC in poorer villages that have, on average, a higher prevalence of female headship, smaller plots of land, fewer livestock holdings, and poorer-quality land (Kumar and Quisumbing 2012b). A female member on the LAC may be better able to reach out to women within households, but having a female member of an important village-level committee is neither a necessary nor a sufficient condition for legal literacy. First, it is possible that women have been appointed to the LAC just to meet requirements. Second, women serving on the LAC have to handle these duties over and above their own productive and domestic responsibilities and may not be that effective. Third, women on the LAC, to be effective as conduits of legal rights knowledge, need to be trained themselves. This suggests that legal literacy campaigns need to be designed to educate grassroots-level LAC members not only in the content of the legal rights provisions but also in mechanisms that are more effective in reaching women in landholding households.

With regard to soil conservation technology practices, a few key findings emerge. First, adoption of SCTs is a labor-intensive process that tends to be higher in households with more labor resources but can be lower in households with higher opportunity costs of labor. Second, biophysical properties of the farm clearly matter, with some types of technologies, such as bunds, being more suitable to low rainfall areas. Third, while the household level of land rights knowledge does not appear to affect the adoption of SCTs, gender gaps in land rights knowledge diminish the probability of adopting SCTs, especially for female-headed households. Last, in no case was the fraction of land registered an important determinant of the adoption of SCTs. With an almost universal rate of land registration, this is no longer the binding constraint to the adoption of SCTs. However, the differential impact of the knowledge scores (as well as the gaps in certain domains) indicates that there is still scope for improving knowledge of the rights embodied in land certification.

Our analysis of the determinants of tree planting shows that on plots managed by males, higher schooling attainment of the plot manager is positively associated with tree planting. While tree planting does not appear to have high labor requirements, larger plots of land are less intensively planted with trees. Plots with good soil are associated with both tree planting and planting of legumes, although it is possible that soil fertility is endogenous—plots where legumes have been planted could be more fertile.

Different bundles of land rights have different impacts on the adoption of specific SCTs: whether the plot is registered increases the probability of planting legumes—in itself a soil fertility investment—while transferability of the plot is associated with higher probabilities of tree planting. Similar to results for male-managed plots, trees are less likely (but legumes more likely) to be planted on large plots that are managed by women. Supporting the hypothesis that transferability increases investments in land, whether the plot can be transferred to others increases the probability of tree planting but not of growing legumes. Household knowledge scores and gender gaps in component scores do not have consistent effects on tree planting at the plot level, and the magnitudes of these effects are small. The desirability of planting specific tree crops or legumes depends on the profitability of the tree crop, its uses, and its biophysical characteristics. At the plot level, land rights knowledge appears to matter less than biophysical characteristics of the plot and transferability.

Increasing the adoption of SCTs and agroforestry in particular, and integrated soil fertility management practices in general, will be increasingly important as part of East Africa's climate change adaptation strategy. While agricultural research centers have directed their efforts to improving these technologies as well as building capacity to implement these through more effective extension systems, the findings from this paper suggest that increasing knowledge of land rights may be equally important, or even more important, in achieving climate resilience in Ethiopia. If security in land rights is no longer a binding constraint owing to gender-sensitive legislation or programs to increase tenure security for women, efforts must be directed toward closing the gender knowledge gap in land rights.

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