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Adoption of Land Management Practices in Ethiopia: Which Network Types Matter?

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Abstract: *In recent years researchers have begun to discuss the impact of social networks on the adoption of land management practices. However, key research questions about both the types of social networks and how specific networks influence adoption are not sufficiently addressed. Using World Bank's data, we fill this research gap by exploring the impacts of three types of social networks (relatives, friendship and neighborhood) on the adoption of soil conservation and tree-planting in the context of Ethiopia. The results show that networks with relatives have a positive impact on tree-planting but its impact on soil conservation is negative. This indicates the presence of "egoistic behavior" even in stronger ties such as relatives. Hence, our conclusion is that farmers tend to plant trees as a means of securing land holdings. However, such "private benefit" incentives may disappear when it comes to soil conservation, which is more of a "social benefit".*

1. Introduction

According to the Intergovernmental Panel on Climate Change (IPCC, 2007), the Horn of Africa is the most vulnerable region in terms of the impacts of climate change. Climate change is defined as *"any long-term and significant change in the expected patterns of a specific region's average weather for an appropriately significant period of time" (Jonathan et al., 2010:1)*. Climate change is manifested in various forms such as increased rainfall intensity; short rainfall duration; and high temperatures leading to increased evapotranspiration and therefore reduction in soil water moisture. Amongst the major effects of climate change are land degradation problems such as accelerated erosion and depletion in soil fertility. These land degradation problems in turn lead to significant reduction in agricultural productivity as the problems are directly related to land, one of the key inputs in agriculture. The various effects of climate change on land degradation culminate in low yields, worsening food security and increasing poverty (Byiringiro and Reardon, 1996; Shiferaw et al., 2007; Bekele, 2005).

Climate change induced land degradation is considered as one of the major reason for low productivity and food insecurity in rural Ethiopia (Kassie et al., 2010a; Kassie et al., 2008; Shiferaw and Holden, 1998; Gebremedhin and Swinton, 2003). Climate change induced soil erosion and nutrient depletion costs Ethiopia nearly 21 to 42 tons of fertile soil per hectare per year on cultivated lands (Hurni 1988). As a result, total crop losses due to erosion and nutrient depletion is estimated to reach up to 10 percent of total production between 2000 and 2010 (Yesuf and Pender, 2005).

Land degradation is more severe in Amhara National Regional State (ANRS), the study area, than any other regions of Ethiopia. According to Desta et al., (2000), 29 percent of the total area of ANRS experiences high erosion rates (51-200 tons per hectare per year); 31 percent moderate erosion rates (16-50 tons per hectare per year); 10 percent very high erosion rates (more than 200 tons per hectare per year) and the remaining 30 percent low erosion rates (lower than 16 tons per hectare per year). The authors further noted that nearly twenty thousand hectares of forest is harvested annually in the region for fuel wood and construction purposes. However, harvested trees are not replaced and, thus, deforestation alone costs the region 1.9 to 3.5 billion tons of fertile soil per year (Desta et al., 2000). Other studies in the region (Benin, 2006) reveal that farmers in ANRS are highly aware of the severity of the land degradation in their farm land and its effect on their production. Increasing productivity and achieving food security through the reduction of land degradation, therefore, requires farmers in ANRS adopt sustainable land management practices.

Since 1991, various land management techniques have been promoted in ANRS (Benin, 2006; Kassie et al., 2010b). These include structural methods (soil and stone walls), agronomic practices (minimum tillage, grass strips, planting tree) and water harvesting (tied ridges and check dams) (Benin, 2006; Desta et al., 2000). Despite the availability of these technologies, the adoption process is slow due to lack of basic infrastructure and resource, weak actor linkages, and top-down approaches (Davis et al. 2010; Spielman et al. 2010). This calls for new approaches that consider farmers' specific needs and encourages their collective action (Birner and Anderson 2007).

One such approach for successful Sustainable Land Management (SLM) is through enhancing farmers' social networks (Foster and Rosenzweig, 1995; Maertens and Barrett, 2012; Matuschke and Qaim, 2009; Bodin et al., 2006; Di Falco and Bulte, 2013). Tompkins and Adger (2004), argue that social networks between farmers can build community resilience and increase adaptation to climate change induced land degradation. However, not all social networks are equally important for adapting to the effects of climate change and therefore dynamic and effective links are needed for SLM practices (Newman and Dale, 2005).

In the case of Ethiopia, farmers have two forms of informal social networks: strong networks (based on bloodline and marriage) and weak networks (non-blood line friendship and neighborhood ties) (Dercon et al., 2006; Di Falco and Bulte, 2013). Both kinds of informal social networks are more complex than conventional "extension" approaches and do significantly influences the adoption of SLM technologies (Spielman et al., 2010; Di Falco and Bulte, 2013). These kinds of informal social networks are especially important for smallholder and resource-poor farmers whose technology needs are not often addressed by formal extension services (Matuschke, 2008). Compared to the formal extension approach, farmers' informal social networks are also both time efficient and cost effective, since these social networks are durable and would not have to be constructed by government agencies (Matuschke, 2008).

The introduction of social networks into SLM studies, therefore, allows for a range of policy alternatives. For example, funds for agricultural extension are declining and extension managers should look for alternative source of funding and move away from *a "one-size-fits-all" thinking to a "best fit" approach* (Birner et al., 2009; Davis et al., 2010). Hence, understanding whether rural social networks matter and which types of social networks matter most for technology adoption needs to be a priority of the current extension system (Maertens and Barrett 2012; Matuschke and Qaim 2009). However, current research in Ethiopia focuses mainly on the effects of network size on technology adoption (Di Falco and Bulte, 2013, Wossen et al., 2013) and there is no empirical study on which types of social networks matter the most, and how do such types of social networks matter for SLM.

The main objective of this paper is, therefore, to fill this research gap by assessing how the different types of social networks are related with the adoption of SLM practices in ANRS of Ethiopia. The paper mainly focuses on the relationships between two important SLM practices (tree-planting and soil conservation) and social networks (relatives, friendship and neighborhood).

The remainder of the paper is organized as follows: Following this introductory part, section two reviews the theoretical links between social networks and natural resource management. Section three presents the description of the data used for the analysis and biophysical characteristics of the study area. Descriptive statistics and regression results will be presented in section four and the main findings from the study are outlined in the concluding section.

2. Social networks and adoption of SLM practices

In the past, researchers have focused on input and output markets, farmers' behavior and quality of extension services as the main determinants of technology adoption (Feder et al., 1985; Rogers, 1995). Application of social networks on technology adoption model is of recent origin (Maertens and Barrett 2012; Foster & Rosenzweig 1995; Savage and Ribaudo, 2013). A social network as defined by (Maertens and Barrett 2012) is *"individual members (nodes) and the links among them through which information, money, goods or services flow."* According to Bandiera and Rasul (2006) and Monge et al. (2008), social networks affect technology adoption through social learning, joint evaluation, social influence, and collective action. Models of social learning hypothesize that, farmers learn about the existence and characteristics of new technology from their friends, neighbors or relatives and take advantage of their networks' experiences during adoption decision (Monge et al., 2008). According to Maertens and Barrett (2012) models of social learning try to answer questions such as what do farmers value and over what time period? What type of information does the farmer absorb and from whom? How do farmers learn or how do they update their beliefs? How do beliefs translate into actions? And do agents interact strategically?.

Research on technology adoption in the context of Ethiopia also shows that farmers with large networks are fast adopters and learners of technology (Gebremedhin and Swinton 2003; Bewket 2007; Kassie et al. 2013). This is because farmers with large network sizes are likely to enjoy more trust among each other and can jointly evaluate new technologies. The joint evaluation will in turn help network members to reinterpret and redefine the technology so that it will become more realistic and meaningful to their local context (Monge et al., 2008).

The literature on social network and resource management also extensively discusses how networks influence individual actors and groups. Social influence refers to *"the enforcement of social norms, opinions and attitudes on individual's preferences and behaviors"* (Monge et al., 2008:9). According to the social influence theory, the outcomes of the network are different for different types of networks, for example, strong networks (comprising relatives)[1] versus weak networks (based on friendship and neighborhoods) (Bodin et al. 2006). Similarly, Prell et al. (2009) notes that actors with strong networks have the tendency to: influence one another more than weak networks; share similar ideas; offer one another emotional support and help during crises; communicate effectively regarding complex issues such as SLM and be more likely to trust one another for risk technology.

Based on the arguments presented above, the benefits of strong networks for SLM are obvious. However, the advantages of strong networks may be countered by the redundancy of information if strong networks are shared for a long period of time. In this regard, several authors (see for example, Bandeira and Rasul, 2006; Besley and Case, 1994; Foster and Rosenzweig, 1995; Munshi, 2004) argued that social networks limit an individual's opportunities for social learning and sometimes may constrain their members from adopting the new technology by limiting membership or participation in a given innovation process. This implies strong ties such as relatives may involve free-riding problems with potential adverse incentives for adopting costly and long term investments on land, such as planting tree and soil conservation (Di Falco and Bulte 2013).

In contrast, diverse information and knowledge may flow best through weak[2] and non-blood line ties, such as friendship and neighborhood ties (Bodin et al. 2006). Research has shown that friendship and neighborhood ties offer farmers access to diverse pools of information and

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[1] In this study, a strong network is defined by bloodline and marriage networks.

[2] In this study, a weak tie is defined by no bloodline and marriage connection.

resources (Bandiera and Rasul 2006; Bodin et al. 2006). Within the context of resource management, friendship and neighborhood ties can make a network more resilient and adaptive to climate change. A potential drawback of friendship and neighborhood ties, however, is that they may be easy to break. In addition, friendship and neighborhood ties may lack the trust and understanding needed for costly and long term investments on land (Newman and Dale 2005).

3. Study area, data and econometric estimation

3.1. Study area

The study was conducted in Amhara National Regional State (ANRS) of Ethiopia. ANRS is located in the Northern western part of Ethiopia covering an area of 150,374 square kilometers and having a population size of over 17 million (Desta et al. 2000). In terms of the traditional agro-ecological classification, the region is composed of 3% Bereha (below 500 masl), 22% Kolla (500-1500 masl), 44% Woina-dega (1500-2300 masl), 27% Dega (2300-3000), 4% Wurch (above 3000 masl) (Desta et al. 2000). The recorded annual mean temperature of the region ranges from 12.4 degree centigrade to 27.8 degree centigrade (Desta et al., 2000).

The pattern of land utilization in the region is as follows: 28.2 percent arable land, 30 percent pastoral land, 2.1 percent forest land, 12.6 percent bush land, 7.2 percent settlement, 3.8 percent water bodies and 16.2 percent unusable land (Desta et al. 2000). The topography of the region is composed of diverse setups, including lowland, midland and highland plains, mountains, rugged lands, chains of plateaus. ANRS is one of the most vulnerable regions to climate change induced land degradation in Ethiopia. Over the last few years, the region has experienced intense rainfall, shorter rainy seasons and higher temperatures which are characteristics of climate change (Yesuf and Pender 2005; Desta et al. 2000).

To counter the effects of climate change induced land degradation, people in the region have adopted land management technologies such as terracing along mountain slopes, water harvesting and tree planting, which help in both preserving soil moisture and increase biodiversity (Desta et al. 2000). Some of these activities are done collectively by community members through well-established community mobilization efforts. At the individual level, farmers in the region have adopted SLM technologies on their plots, mainly soil conservation techniques (soil and stone walls) and agro-forestry (tree planting) (Benin 2006; Mekonnen 2009).

3.2. Data and discription of variables

For the analysis, the Farmer Innovation Fund (FIF) data of the World Bank gathered during 2010 was used. The survey was administered by the International Food Policy Research Institute (IFPRI) with the support from the Ministry of Agriculture and Rural Development of Ethiopia and the World Bank. A multi-stage stratified sampling procedure was followed, in which FIF project woredas (districts) were first randomly selected within each agro-ecological zone, followed by kebeles (sub-districts) and then, ultimately, households. Using this method, 19 kebeles and between 35 and 88 households in each kebele were randomly sampled. Two respondents were interviewed in each household, the main respondent (generally a male head), and a second respondent (a female spouse in male-headed households, or "other main farmer" otherwise).The dataset used in this study combines responses from both interviewees, for a total sample size of 1338 households. The dataset has detailed information on household characteristics, agro-climatic zones, production (crop, livestock and nonfarm activities), input use (fertilizer, chemicals and seed), and institutional services (credit, extension service, technology adoption, groups and networks). Such data set are rarely available in developing countries.

Table 1 presents descriptive statistics of the dependent and explanatory variables. Following the literature on the role of networks in determining technology adoption (Di Falco and Bulte, 2013; Wossen et al., 2013; Maertens and Barrett, 2012; Bandiera and Rasul, 2006), we expect that farmers may adopt SLM technologies from their relatives, neighbors or friends through social learning processes. The data set provides detailed information on how many farmers adopted soil conservation and tree planting and how the social learning may have taken place. Farmers were asked *"what types of long term investments have you made on this plot in the last 12 months?" and "who do you speak with the most, excluding development agent, about natural resource management?"* Farmers' networks were classified according to a taxonomy of "types of social networks" applicable across all study areas, which included the categories of relatives, friends and neighbors. Following Di Falco and Bulte (2013) and Wossen et al., (2013), the networks of relatives in this study comprise bloodline and marriage ties including nephews, nieces and in-law families.

With respect to our target variables and when sampled farmers were asked with whom they had spoken the most (where each farmer may respond more than once if using more than information source) about tree planting and soil conservation: on average 21% of the farmers responded that they received advice from relatives, of whom 71.7% adopted tree planting and

29.3% adopted soil conservation; 27% of the farmers received advice from neighbors, of whom 23.2% adopted tree planting and 70.2% adopted soil conservation; 36% of the farmers received advice from friends, of whom 21.4% adopted tree planting and 20% adopted soil conservation.

Besides the informal networks, cooperatives and extension services constitute also formal networks widely used for technology adoption in Ethiopia. Nearly 78% of the farmers have received advice on SLM from extension workers. Iqqub and Iddir are other important indigenous local institutions (informal associations) in Ethiopia that are providing self- help against risks. Iqqub provides rotating savings and credit services, while Iddirs are established for providing mutual aid during death of members (Di Falco and Bulte 2013; Dercon et al. 2006). These indigenous institutions are not only providing self-help services, but also serve as a forum for discussing social and technological issues.

Data was also collected on farmers' household characteristics, their plot characteristics, land-tenure, wealth, as well as geographic location. The average age and education level of the head of the household is 42 and 2 years respectively with a family size of 6 people. 66 percent of the head of the households responded that at least one member of their family worked on someone else's land or in some other employment, against payment in cash or in kind. The off-farm employment also involves participation in the Productive Safety Nets Programme (PSNP)[3] .

Farm characteristics are represented by soil quality and slope. Based on farmers' self-assessment of their plots, soil quality is rated as fertile, medium or infertile. Similarly, depending on the slope; farmers categorize their plot as flat, gentle or steep slope. Climatic conditions are represented by traditional agro-ecological zones; Dega, Woina-dega and Kola. While the survey distinguishes many categories of livestock ownerships, we aggregated these categories together into one asset indicator called Tropical Livestock Unit (TLU) using FAO conversion factor.

[Insert Table 1]

[3] PSNP provides cash or food for people who have predictable food needs in exchange for public work to protect environmental degradation.

3.3. Econometric estimation

To investigate how social networks determine farmers' adoption of two important land management practices (tree-planting and soil conservation), the paper estimated plot-level probit models using cross-sectional data. Using this model, the paper also tested the hypothesis that farmers who communicate most with relatives tend to implement more of tree-planting and soil conservation due to strong ties. Following Di Falco and Bulte (2013) approach, the model is specified as;

$$\mathrm{Y}_{\mathrm{hi}}^{*} = \mathrm{Y}(x_{hi}, x_{hi}^{p}, x_{hi}^{n}, x_{hi}^{a}; \beta) + e_{hi} \qquad (1)$$

The adoption decision (Y_{hi}) of household i is assumed to depend on a set of explanatory variables such as household characteristics x_{hi}, plot characteristics x_{hi}^{p}, as well as on the household's interaction with social and other networks x_{hi}^{n}. We also include agro ecology x_{hi}^{a} to control for location differences that may influence adoption. β is a vector of parameters to be estimated and e_{hi} is the error term assumed to be normally distributed and uncorrelated with any of the variables. Adoption of soil conservation and tree-planting (Y_{hi}) was modeled as binary choice problem {0, 1}, and hence for the latent variable Y_{hi}^{*}, the estimation is based on the following observable binary choice of adoption or non-adoption of tree-planting and soil conservation.

$$Y_{hi} = \begin{cases} 1 & \text{if } \mathrm{Y}_{\mathrm{hi}}^{*} > 0 \\ 0, & \text{Otherwise} \end{cases} \qquad (2)$$

Where x_{hi} refers to variables that affect soil conservation and tree planting. These include: household characteristics x_{hi} (age, education, off-farm job, household size, asset); plot characteristics x_{hi}^{p} (soil fertility, slope); Social networks x_{hi}^{n} (relatives, friends, neighborhood) and other networks such as group participation (formal and informal, cooperatives) and institutional networks (extension and land tenure). Asset holdings are represented by Tropical Livestock Unit (TLU) and plot location by agro-ecology (x_{hi}^{a}).

Since a household-level model does not capture plot specific characteristics (soil quality and slope) and other important determinants such as land tenure, we estimate a plot level model as in Di Falco and Bulte (2013). The plot varying effects are taken care of by running a random effects model where the mean values of plot-varying explanatory variables are included (pseudo-fixed effect model) to control for unobserved heterogeneity (Mundlak, 1978; Wooldridge, 2002; Di Falco and Bulte 2013; Wossen et al, 2013). As in Mundlak (1978) and

(Di Falco and Bulte 2013) the auxiliary regression model that included the mean values of the plot varying covariates is specified as:

$$e_{hi} = \alpha\overline{\chi} + \omega_h\,, \quad \omega_h \sim iid(0, \delta_w^2) \qquad (3)$$

Where $\overline{\chi}$ represents the mean of the plot-varying explanatory variables within each household (cluster mean), α is the corresponding vector coefficient, and $\omega_{i,}$ is a random error term uncorrelated to the explanatory variables. The advantage of this Mundlak model specification is that it allows controlling for plot-varying explanatory variables (slop, soil fertility, land tenure) as well as measuring the effects of plot-invariant household variables specified in equation 1. In effect, the Mundlak specification unifies both the fixed and random effects estimation approaches. One potential problem of the model specification could be the endogeneity of social network variables. Social network variables, such as the size of relatives and friends networks, may vary depending on the wealth status and other unobserved household characteristics. In our case, we assumed (as in Isham 2002; Di Falco & Bulte 2013) that our variables are exogenous for the following reasons. First, our social network variables measure network type instead of size. This reduces the potential endogeneity problem as the quality of information (trust) from such networks is more important than the size of networks in the adoption decision. Second, we used Mundlak's (1978) approach, which eliminates the endogeneity problems caused by plot invariant unobservable effects as the mean values of plot-varying explanatory variables are included (pseudo-fixed effect model) to control for unobserved heterogeneity.

4. Regression results

Plot-level results of the probit models are presented in Table 2. Given the objectives of this paper, the analysis focuses mainly on the impacts of social networks on soil conservation and tree-planting. The first model shows the effects of three social network types, i.e., networks with friends, neighbors and relatives, on soil conservation and the second on tree-planting.

In the first model, we found that information exchange with relatives will decrease the probability of investing in soil conservation by 7 percent. Using kinship size as a measure of networks, Di Falco and Bulte (2013) also found the same negative relationship between kinship ties and adoption of soil conservation in Ethiopia. But many of the previous studies documented a positive association between relative networks and adoption of new technologies (e.g., Bandiera et al., 2006; Isham, 2002). The difference between our findings and many of the previous studies might be due to variations in measurement of networks.

Unlike our paper, the other studies represent networks either by network size (Di Falco and Bulte 2013) or membership to network. The negative relationship between relative ties and soil conservation in our case and as argued by (Di Falco and Bulte 2013) might be due to potential free riding problem or adverse incentive induced by relative relations[4]. For friendship and neighborhood based network ties, we found insignificant effects for the adoption of soil conservation.

For the second model, a different result, showing a positive relationship between networks with relatives and planting trees was obtained. This result is similar with (Di Falco and Bulte 2013) findings and supports the view that tree growing is used as a means of securing land holdings in Ethiopia (e.g., Deininger and Jin, 2006; Mekonnen, 2009). Di Falco and Bulte (2013), argued that due to common heritage and bloodlines, farmers may resort to planting tree when faced with the risk of losing their land to kinship members. Their preposition is supported by our model as we also found negative relationship between planting tree and land tenure security. According to our model, securing land rights through certification reduces the probability of planting tree by approximately 10 percent. This is an indication that when land tenure security is realized through certification[5], tree planting might not essentially serve as a means of securing land holdings.

Neighborhood ties also positively influence households decision to invest in planting tree. The average marginal effect shows that the probability of tree planting will increase by 6.2 percent. Regarding the other community networks, becoming a member of formal association (credit and saving associations) increases the probability of planting tree by 12% while membership to informal associations (Iqqub and Iddir) and cooperatives decreases that probability, respectively, by 14% and 12%.

Looking at the non-network variables, farmers do more SLM on highlands (Dega and Woina-dega) than on lowlands (Kolla). Farmer’s probability of planting trees and conserving soil is respectively 14 percent and 21 percent higher in Woina-dega than in Kolla. Similarly, farmers’ inclination to planting trees is 19 percent higher in Dega than in Kolla.

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[4] For example, Guirkinger and Mali (2011) referred these kinship ties as “forced solidarity”.

[5] Saint-Macary et al. (2010) also found that in the absence of a reallocation threat, land titles do not influence agroforestry adoption in Vietnam.

Regarding the other socio-economic variables, average education significantly influences soil conservation but not planting trees. This indicates that soil conservation is a more labor and knowledge intensive[6] technology than planting trees. According to our model, an additional year of experience raises the probability of soil conservation by 0.5 percent. Average household size positively and significantly influences both planting trees and soil conservation. On the other hand, one unit increase in Tropical Livestock Unit (TLU) will decrease the probability of soil conservation by 2.5%. Finally we are interested in farmer's interaction with the outside world through extension. The extension network as represented by contact with the development agents is insignificant for both soil conservation and planting trees.

[Insert Table 2]

5. Conclusion

In recent years, researchers have begun discussing the impact of social networks on the adoption of sustainable land management practices. However, key research questions such as which types of social networks matter most and how do specific network types matter, are not addressed fully in contemporary network studies. Engaging with some recent studies on social networks (e.g. (Di Falco and Bulte 2013; Maertens and Barrett 2012; Bandiera and Rasul 2006) and using the FIF data of the World Bank, we have tried to fill this research gap by exploring the impact of three types of social networks (relatives, friendship and neighborhood) on soil conservation and planting trees. Our findings show that networks with relatives have a positive impact on planting trees but its impact on soil conservation is negative. This suggests the presence of "egoistic behavior" even in stronger ties such as that of relatives. When farmers are faced with the risk of losing their land to relatives, due to common heritage for example, they tend to plant trees as a means of securing land holdings. The benefits of planting trees can be privately accrued should farmers lose their land holding rights to relatives. However, such private benefit incentive may disappear when it comes to soil conservation, which is more of a "social benefit".

[6] According to Kassie et al. (2008), construction of walls requires as much as 100 person days on a small quarter-hectare plot.

The findings revealed that similar to common resource management problems, networks with relatives may induce adverse incentives (free riding) on soil conservation as the opportunity cost is high compared with planting tree - taking up to 10–20 percent of cultivable area and 100 person days to construct a bund[7] on a small plot (Shiferaw and Holden 1998). On the other hand, friendship networks were found to be insignificant in both planting trees and soil conservation. This suggests that the potential contributions of friendship networks that can significantly affect SLM remain untapped.

Extension network is not found to be an important determinant of soil conservation and planting trees. This is worrying given the substantial role extension workers should have played in SLM. Although the extension service in Amhara region has a strong foundation of Farmers Training Centers (FTCs) and trained development agents (DAs), they are providing little service on SLM due to lack of infrastructure and resources (Davis et al. 2010). This might have forced DAs to focus only on relatively short term results such as crop and livestock and the long term and costly practices of SLM might have taken a back-seat.

The roles of local institutions (cooperatives and land tenure) need to be revisited as well. For example, cooperatives should incorporate SLM in their development agenda in addition to their current role of distributing agricultural inputs. As we witnessed during our field visit, land registration in the region entails a long procedure[8] and obtaining maps of land holdings is very difficult. From the overall sample, only 20 percent of the farmers had secondary certificate and until this study was conducted, no farmer had a map of land holdings. Even though farmers may receive a map of land holdings in the future, we are afraid their probability of making a long term investment in planting trees and soil conservation might still be jeopardized as the land belongs to the government and it is not subject to sale or to other means of exchange.

[7] Kassie et al. (2008) found a negative effect of fanya juu walls on yields in Ethiopia.

[8] Land registration involves at least seven steps: preparation and awareness raising, application and identification, temporary certificate, public hearing, registration, primary certificate and secondary certificate.

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Tables

Table 1: Variable list and descriptive statistics

Variable	Mean	Std dev	Min	Max
Friends (1= information from a friend, 0= otherwise)	0.36	0.48	0	1
Neighbours (1= information from a neighbour, 0= otherwise)	0.27	0.44	0	1
Relatives (1= information from a relative, 0= otherwise)	0.21	0.41	0	1
Household size (family members)	6.0	2.0	1	14
Age of household head(in years)	42.0	10.75	18	82
Sex household (1= male, 0= female)	0.77	0.42	0	1
Education (head)	2.45	2.82	0	14
Access to off-farm (1=yes,0=otherwise)	0.66	0.47	0	1
Soil fertility[9](1=Lem, 2=Lem-Tef, 3=Tef)	1.82	0.51	1	3
Access to extension (1=yes,0=otherwise)	0.78	0.42	0	1
Slope (1= flat, 2= medium,3=step)	1.22	0.36	1	3
Land tenure[10] (1=yes,0=otherwise)	0.73	0.44	0	1
Informal associations (1= member, 0=otherwise)	0.77	0.42	0	1
Formal associations (1= member, 0=otherwise)	0.03	0.16	0	1
Agricultural cooperatives (1= member, 0=otherwise)	0.03	0.18	0	1
Tropical Livestock Unit (TLU)	0.13	0.73	0	23
Agro-ecology (1=Dega, 2= Woina-dega, 3=Kolla)	2.22	0.50	1	3

[9] Lem, Lem-Tef and Tef are traditional soil quality categories representing respectively; fertile, moderate and infertile soil.

[10] Land holding is said to be secured when the household receives a certificate and can transfer the land.

Table 2: Probit regression results on the effects of Networks.

	Soil conservation (dy/dx)	Planting tree (dy/dx)
Fertile soil	-0.001161	-0.002236
	(0.041)	(0.040)
Medium soil	-0.019879	0.006603
	(0.029)	(0.029)
Steep slope	-0.053844	0.086735
	(0.081)	(0.079)
Middle slope	0.018005	-0.029181
	(0.029)	(0.029)
Land tenure	-0.030888	-0.100505***
	(0.018)	(0.021)
Household size	0.013357**	1.3165**
	(0.005)	(0.005)
Sex	0.169003	-0.267514*
	(0.097)	(0.117)
Age	0.004505***	0.001783
	(0.001)	(0.001)
Education	0.006999*	0.001241
	(0.003)	(0.003)
Access to off-farm	-0.016672	0.023265
	(0.020)	(0.020)
TLU	-0.024784***	-0.000941
	(0.005)	(0.004)
Friends	0.036857	0.019178
	(0.025)	(0.024)
Neighbors	-0.040283	0.062450**
	(0.025)	(0.025)
Relative	-0.069939**	0.092374***
	(0.025)	(0.025)
Membership to formal association	0.011797	0.127322*
	(0.050)	(0.057)

Membership to informal association	0.048667*	-0.140349***
	(0.025)	(0.026)
Membership to agri-cooperatives	-0.097715	-0.120621***
	(0.052)	(0.028)
Extension service	0.030673	0.027514
	(0.023)	(0.021)
Dega	-0.030174	0.193837**
	(0.042)	(0.063)
Woina-dega	0.137558***	0.209744***
	(0.025)	(0.018)
Plot fixed effect	Yes	Yes
N	2503	2503
Pseudo R2	0.0881	0.0867

Standard error in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$