

Conservational Tree Growing by Smallholder Farm Households: Evidence from Gamo Highlands of Southern Ethiopia

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Abstract

Background: Deforestation and environmental degradation were identified among the leading factors worsening risk exposure in developing countries. Conservational tree growing was found a permissible option and an awake up policy direction to curve down the problem in Ethiopia. However, the uptake of this practice is far from complete and the art has not been made to a level that could make households self-reliant at least in tree resources, particularly in the highlands. This study was aimed at identifying the main decisive factors that potentially influence conservational tree growing behavior of smallholder farm households in Gamo highlands of Southern Ethiopia.

Methods: The study was based on survey data collected from 11 villages in 2011/2012. A multi-stage sampling technique was used to select 335 farm households. A structured interview schedule and observation were used to collect primary data. Descriptive and inferential statistics and Logistic regression model were used to analyze the data.

Results: The key findings showed that a host of factors significantly influenced smallholders' decision to practice conservational tree growing. The study found that tree growing experience, age of the household head, farm size, and availability of suitable land area for tree growing and cash income from sales of trees were the significant factors explaining the variation in conservational tree growing behavior of households. The study also observed that indigenous social and cultural organizations and religious and old-aged funeral sites were the homes for old-aged but live indigenous tree species than private farms.

Conclusion: Based on the findings, the study concluded that intra-farmer experience sharing, and support to efficient indigenous institutions and rural tree markets as potential entry points for mitigating deforestation, improving forestry, and developing environmentally sustainable agriculture.

Background

Risk exposure identified as one of the typical features of farming in developing countries limits income generating and hence affects welfare gaining capacity of farmers (Dercon 2004). The problem is serious in the horn of Africa where the landscape of the economy is dominated by rain-fed smallholder agriculture (Fulginiti et al., 2004; IPPC 2007; FAO 2011; FAO et al., 2011). Ethiopia suffers the problem seriously (FAO 2001; Di Falco and Chavas 2009) and there exist plenty of evidences that explore worse existence of such events in the highlands of the country (FAO 1984; Bishaw 2001; Pender et al., 2001; Dercon 2004; Pender and Gebremedhin 2007; Di Falco and Chavas 2009; Bekele and Mekonnen 2010; Zeleke and Bliss 2010; FDRE 2011).

Deforestation was identified among the leading factors worsening the aforementioned problems. It intensifies environmental degradation, global warming, biodiversity loss and desertification and aggravates farmers exposure to regular weather shocks, climate change, and crop failure (Bishaw 2001, 2009; Bekalo and Bangay 2002; Dercon 2004; IPCC 2007; Yesuf et al., 2008; Bekele and Mekonnen 2010). With these externalities, market prices fail to reflect resource scarcity and individual members face

insufficient incentives to adopt eco-friendly measures. This is serious in areas where people's livelihoods heavily depend on forest resources (Tietenberg 1992) implying a key to a sustained increase in farm productivity and agricultural output in vulnerable areas such as Ethiopia in general and in the Ethiopian highlands in particular is through better and more effective use of technologies conserving land and biological resources.

Empirical studies identify variety of technologies that enhance agricultural productivity, rural income and the environment. Agro-forestry and conservational tree growing (Bishaw 2001, 2009; Abebe 2005; Deininger and Jin 2006; Zeleke and Bliss 2010), tillage and composting (Kassie et al., 2009), soil bunding (Bekele 2005), and terracing (Deininger and Jin 2006; Pender and Gebremedhin 2006; Kassie and Holden 2006) are appealing options available in Ethiopia.

Among others, tree growing founds a permissible option at least for some basic reasons. They are visible investments consistent with the notion of sustainable development set forth by the world commission on environment and development as well as can serve as a solution to the falling farm productivity and per head incomes observed in the last decades (see for example World Commission on Environment and Development (WCED) 1987; Deressa et al., 2009; Molua 2009; Pender and Gebremedhin 2007; Kassie et al., 2008; Kassie et al., 2009; Kassie et al., 2010; Melillo et al., 2011; Di Falco et al., 2011). Trees can also uphold soil moisture, maintain biodiversity balance, safeguard erosion, reverse land and biological degradation, conserve organic matter of the soil and reduce soil nutrient loss, provide shades for crops, and improve land productivity (Bishaw 2001; Kassie et al., 2010). As trees rely to a greater extent on renewable local and farm specific resources (Lee 2005), they can expand income generating opportunities for the poor, and hence resolve financial risk of buying technology inputs and food goods (Hogset 2005). Similarly, trees can support food security by either directly producing food goods or indirectly providing inputs for the production of food goods and/or supplying fuel-wood for cooking food (Belsky 1993). Based on these evidences we trust that conservational tree growing is a solution for environmental degradation, agricultural productivity, biodiversity balance, poverty reduction and hence for sustainable development.

Conservational tree growing is an awake up policy direction in a recent Ethiopia though not new. Chiefly, it is strongly promoted as part of climate resilient green economy (CRGE) strategy plan 2011 (FDRE 2011) as well as an initiative to reverse the extensive land degradation, to protect the adverse effects of environmental degradation and climate change, and to build a green economy that realize the country's ambition of reaching middle income economy before 2025 (FDRE 2011). Being a traditional technology one can expect that trees can be adopted with less risk as traditional practices in agriculture have been perceived as less risky than modern innovations (Feder et al., 1985; Griliches 1957). Puzzling, the uptake is far from complete and the art has not been made to a level that could make households self-reliant in tree resources, particularly in the highlands.

However, large differences observe between households and villages. Some farmers and villages extensively plant and grow trees while some others do small and the rest do none (Abebe 2000; Admassie

2000; Bishaw 2001; Bekalo and Bangay 2002; Zeleke and Bliss 2010) implying that the past re-afforestation programs launched in Ethiopia were not based on clear understanding of the incentives of and constraints on growers behavior. Simply, by expecting all farmers as an agent who can plant and grow more number and species of trees as long as seedlings are available, seedling were supplied from public nurseries at least at free of charge or at subsidized prices (Zeleke and Bliss 2010). Thus, what determines conservational tree growing by households remains the central question of this study. Therefore, this study aimed to analyze and identify the main decisive factors that potentially influence conservational tree growing behavior of smallholder farm households in Gamo highlands.

Several factors might explain the variation in conservational technology adoption across households. Extension service, agro-ecology, availability of inputs, farm size, culture of people, institutions, proximity to markets, the return from the adoption, risk behavior of adopters, availability of initial capital and other socio-economic and demographic characteristics can determine technology adoption behavior, particularly in agriculture (Kassa 2003; Kebede and Yamoah 2009; Udry 2009). Factors affecting farmers' decision to plant and grow trees in Ethiopia have also been studied in Ethiopia (see for example, Zeleke and Bliss 2010). However, the scopes are narrowly defined with no or limited emphasis to conservational tree growing behavior. Thus, applied to Gamo highlands, we estimate factors meaningfully determine the variation in the adoption behavior of smallholder households towards conservational tree growing (OFATR). OFATR in this study refers to growing a mix of both indigenous and non-indigenous trees specific to the study area else otherwise. We find some important results that suggest smallholders fail to adopt OFATR or encouraged to adopt OFATR not because of knowledge and information gaps. We also observe that cultural, religious, and old-aged funeral sites as a potential source for collecting extinct indigenous treespecies in Ethiopia.

Materials And Methods

Description of the study area

The study area, Gamo highlands, lies in a remote part of Ethiopia, within the former Gamo-Gofa province of Southern Ethiopia, some 500 kilometer to the south of Addis Ababa, the capital of Ethiopia. Gamo-Gofa is one of the ten administrative zones with total population of 1,595,570 in 2007 of which more than 90% lives in rural areas and the majority are in the highlands (CSA, 2008). The zone has a total area of 12,581.4 square kilometer and consists of 15 districts (namely, Arbaminch Zuria, Kucha, Kemba, Boreda, Chench, Daramalo, Dita, Zala, Melakoza, Bonke, Ubadebretsehay, Mirab-Abaya, Geze-Gofa, Demba-Gofa, and Oyda) and two town administrations (Arbaminch and Sawula).

Rising up from the west of twin lakes Abaya and Chamo, Gamo highlands reach an altitude of 4200 meters above sea level at mount Gughe, the highest peak in SNNPR region of Ethiopia. Gamo highlanders, who reside along the undulating chains of this mountain, form the larger proportion of the 1,595,570 population of the Gamo-Gofa province in 2007 (see also CSA 2008). The economy of people in Gamo highlands, like many other rural areas in Ethiopia, depends on agriculture, which feed and

economize almost all the people in the area. More than 90% of the populations depend on the products from this sector. Cultivation of 'Enset', potato and cereals (such as Barley and Wheat) form the basis of subsistence in the higher altitudes while Maize and Sorghum are important food sources on the lower slopes.

In Gamo highlands, natural resources can be considered as opportunities and threats to the lives, if unmanaged. For example, the monsoonal rains and deep aquifers streaming from top highlands continuously feed the Sago, Zage, Maze, Domba, Deme, Kulano, Gogora, Saware, Wajifo, Baso, Harre, Kullufo, Sile and Elgo rivers. These in turn wear down and provide water and eroded loam soil for the people and the fertile fields in the lowlands (Desalegn 2007). Factually, the land of Gamo highlands were believed rich and referred as land of loam soil called 'ModhdhoBiita' (Malebo 2005). It was used to serve as a drought season home for the nearby lowlanders. But now days, things have been reversing back. As a result, the livelihoods of people in more recent times in Gamo highlands would tend to depend on subsistent agriculture and some off-farm economic activities such as labor-intensive petty trade, traditional weaving, wage work, and collection and sale of firewood are the outshining alternatives.

Associated with environmental degradation, the unsustainable use of natural resources, poor performance of the agricultural sector and few opportunities for generating income to people in the area, the traditional labor-intensive weaving, which was believed innovated by one of the Gamo tribes called 'Dorze' in Chench district, as an off-farm income generating activity, has been pushing significant proportion of the highlanders (including school age children) to migrate to the urban areas in other parts of Ethiopia. The problem is aggravated by the fact that population pressure and its density are high; most farmers run small-scale agricultural production that characterizes fragmented land holding and subsistent farming and farm productivity is poor to meet an ever-increasing food and material need of the people. However, sufficient rainfall, deforestation, poor land management practices, environmental degradation, soil erosion, soil infertility, population pressure, poor agricultural productivity, crop failure, and absolute poverty are the primary challenges hindering development in the Gamo highlands (Malebo 2005).

Materials

The data used in this study sourced from five districts located in Gamo highlands (Chench, Dita, Deramalo, Arbaminch Zuria, and Bonkie). We used detailed structured questionnaire survey for face-to-face personnel interviews with smallholder household heads who reside in eleven peasant associations or 'kebele' (the smallest administrative unit in Ethiopia) that were selected from the aforementioned five districts. The survey was conducted in 2011/2012. The questionnaire was developed using a lesson acquired through informal pre-survey interviews with key informants of officials and professionals. The identification strategy followed sequential stages. First, as the role of heterogeneity across agents has been recognized in the adoption literature (Feder et al., 1985), we purposively selected five districts that

characterize varying agro-ecologies and tree coverage. Second; we randomly selected representative peasant associations from each district. Lastly, 335 proportionately sampled households were selected.

Agricultural extension workers working and living in each peasant associations carried out the survey. The interviewers got training about survey questioner and data collection techniques before the survey kicked off. The focal person for the interview was the head of the household. Household heads as a manager of the household has relatively a wider availability of farm information and knowledge than anyone else in the household (Malebo 2005). Thus, they are the first line people who make almost all economic decisions refer to the household. We also conducted focused group discussions with government officials and professionals and direct personnel observation. These all enabled us to collect unflinching data that covered a broad range of socio-economic, demographic, institutional, behavioral, and farm specific characteristics.

Methods

Determinants of technology adoption and the hypotheses on conservational tree growing adoption

Traditionally, the literature on the adoption of agricultural technologies (or failure thereof) has focused on broad range of factors counting socio-economic, demographic, institutional, behavioral, and farm specific characteristics. Among others, perfection of information, availability of inputs, infrastructure, institutional constraints, and human capital found potential factors that explain variation in the adoption decisions (example, Foster and Rosenzweig 1995). Table 1 describes the determinants of conservational tree growing (OFATR) with their corresponding expected hypothesized relationships, and the significance of these factors in the adoption of conservational tree growing is exhaustively explored in latter stage of the paper.

- **Demographic and socio-economic factors**

A. Demographic Factors

Most empirical studies measure demographic factors either by labor availability, sex as a proxy for gender, age and family size. Planting, nursing, and growing trees are labor-intensive endeavors in the study area. We expect that labor constraints can limit the adoptions. Arguably, the larger family size (FAMS) can associate with larger number of labor force and hence with larger number and category of trees grown. Likewise, younger people have a greater chance of acquiring and applying new knowledge and skill than older people (Rogers 1995; Sidibe 2005). In contrary, across age, people can develop experience and skill of doing things. These can make the age effect on tree growing behavior dilemmatic. Thus, we were unclear to hypothesize the role of household head's age (AGE) on the adoption of OFATR but expect a positive influence of family size on OFATR adoption behavior of smallholders (Table 1).

Gender (GEND) is another demographic factor that can influence the extent of adoptions. Being female or male-headedness proxy our gender variable. Females in the study areas play a role of household heads if and only if they were divorced or unmarried at all; if their husbands were dead; or when their son is too child to lead the household (Malebo 2005). This suggests the possibility that labor supply would tend to be short of with female-headedness. Owing larger labor force demand for OFATR adoption, we hypothesized a negative influence of female-headedness (GEND) or a positive influence of male-headedness and a positive association of active labor force (ACLF) availability to OFATR adoption (Table 1).

B. Socio-economic Factors

Socio-economic factors are also assumed to influence the adoption decisions. We use education, occupation, and wealth of the respondents as proxy. Technology adoption literature explains an easier and well familiar adoption of agricultural technologies with higher levels of education and training than those with lower levels (Tassew 2004; Sidibe 2005). Availability of skilled labor can ease such opportunities and likely to influence current technology adoption behavior of households. Thus, we hypothesized a positive influence of education (EDUC-CAT), tree growing experience (TGEXP), and training (TRAIN) on the adoption of OFATR. However, as labor demand in agriculture varies across seasons (peak during planting and harvesting and off-peak otherwise) the occupation variable (OCCUP) might dually influence on OFATR adoption (Table 1).

On the one hand, sufficient availability of off-farm economic occupation can minimize work avoidance during off-peak periods. This might help to generate more income for those who supply more labor hours away from the household. Accordingly, one can expect positive income effect of off-farm occupation for the adoption of farm technologies as it can build farmers ability to invest in productive technologies and other high pay-off inputs and avert risks associate with the adoption. Yet, there are evidences that report negative role of off-farm economic occupation for the adoption of on-farm soil conservation measures. Abera's (2003) study in Ethiopia estimates that off-farm economic occupations constrain household labor supply to on-farm economic activities. However, we expect that a household's sole dependence on on-farm incomes and generation of cash income from tree (YTR) can force them to plant more trees. Consequently, we hypothesized positive link between YTR and OFATR and remained unclear to hypothesize the association between off-farm occupations (OCCUP) and OFATR adoption (Table 1).

Table 1
Determinants of OFATR with expected hypothesized relationships

Acronym	Description of variables	Measurement	Expected sign
Dependent variable			
OFATR	Whether a household adopted conservational tree growing or not	Dummy (1 if grows ecological trees including a mix of indigenous species, 0 otherwise)	
Independent variables			
1. Demographic and socio-economic factors			
FAMS	Family size of the household	Number of people in the household	+
AGE	Age of the household head	Formal age in number of years	?
GEND	Sex of the household head	Dummy (1 if female, 0 if male)	
EDUC	Formal educational background of the household head	Categorical variable (Cannot read and write or no schooling = 1, grades 1–4 = 2, grades 5–8 = 3, grades 9–12 = 4, and grades above 12 = 5)	+
OCCUP	Occupation background of the household head	Dummy (1 if farming only, 0 if both farming and others)	?
YTR	Source of household's income	Dummy (1 if collects cash income from trees, 0 otherwise)	+
ACLF	Active labor force in the household	Number of active labor members	+
TRAIN	Training received about the role of tree growing in environmental conservation	Dummy (1 if yes, 0 if no)	+
TGEXP	Tree growing experience in the past	Dummy (1 if yes, 0 if no)	+
2. Agro-ecological and farm specific factors			
SULNTR	Availability of suitable land area for tree growing	Hectares of land area owned by the household and located on sloppy mountainous areas	+
FARMS	Farm size of the household	Total hectares of land owned by the households (in hectares)	+
AVATR	Sufficient availability of seedlings	Dummy (1 if yes, 0 if no)	+
Source: Authors' compilation			

Acronym	Description of variables	Measurement	Expected sign
HPP	High potential perennial agro-ecological zone	Dummy (1 if the respondent belongs to HPP zone, 0 otherwise)	
HPC	High potential cereal agro-ecological zone	Dummy (1 if the respondent belongs to HPC zone, 0 otherwise)	
LPC	Low potential cereal agro-ecological zone	Dummy (1 if the respondent belongs to LPP zone, 0 otherwise)	
Source: Authors' compilation			

Agro-ecological And Farm Specific Factors

Farm size, land suitability, and proximity of farms to the nearest input and output markets are among the agro-ecological and farm specific factors assumed to determine technology adoption behavior. Agro-ecological factors were proxies by agro-ecological zones of the respondents. The agro-ecological zones of Ethiopian highlands were classified into three broad major categories: (i) the high potential perennial (HPP) zone, (ii) the high potential cereal (HPC) zone, and (iii) the low potential cereal (LPC) zone (Table 2). These often were defined in terms of temperature, stored soil moisture and number of days in a year that plants grow without irrigation (Bishaw 2009).

We included these agro-ecological variables to control for all the unobserved agro-ecology specific factors associate with the adoption OFATR of in the smallholder farmers. We expect larger adoption of conservational trees in LPC zone than the other two as it characterizes high variability of climate and occasional occurrence of droughts (Bishaw 2009).

Table 2
Major Agro-Ecological Zones of the Ethiopian Highlands

Agro-ecological zones	Climate	Growing period in number of days
HPP zone	Warm and more humid	Mainly > 240
HPC zone	Intermediate rainfall	Usually > 180
LPC zone	High variability and occasional drought	Mainly 90–150
Source: Bishaw (2009)		

As far as farm specific factors are concerned, we use farm size, land suitability for tree growing and sufficient availability of seedling sources. A basic possible hypothesis on-farm size is that the adoption of an innovation will tend to take place earlier on larger farms than on smaller farms. This can be largely due to cost issues. For instance, Feder and O'Mara (1981) demonstrate that fixed transaction costs associated with the adoption innovations prevents small farms from adopting technologies. Land ownership can also influence land related investments by many other ways. The larger the farm size (FARMS) a farm household owns the more land area can be accessed for planting and growing trees. Land suitability for tree growing (SULNTR) is another farm specific factor that might influence farmers' technology adoptions; the availability of more mountains land area, the greater the likelihood of adopting conservational investments. Sufficient availability of seedling sources (AVATR) is also basic as investors use factor inputs for production. We thus expect that OFATR is positively associated with SULNTR, AVATR, and FARMS (Table 1).

Model Specifications

The analysis and presentation of the study was quantitative. To this end, the data were quantified to scores as shown in Table 1 and the analysis employed a mix of both descriptive statistics and econometric tools. Initially, the inter-relation between the potential predictors was analyzed by spearman correlation and then regression analysis was utilized principally. Since our observations take limited categories with zero values on the dependent variable the orthodox Ordinary Least Squares (OLS) regression models cannot properly accommodate the data. This failure directed us to utilize estimators built on the principle of maximum likelihood (MLE) estimators. The most common of these models used in the adoption literature are the logit and the probit. As Anemiyi (1985), Wooldridge (2000) and Verbeek (2004) conclude that the choice of which model to use cannot be justified theoretically. They estimate almost similar results. However, there are empirical suggestions that force us to prioritize between them. Arguably, logistic regression analysis provides response probability estimates that are asymptotically consistent and computationally easier to use than probit (Pindyck and Rubinfeld 1981).

Following this framework, logistic modeling approach founds customary in empirical studies that examine factors determining technology adoption, particularly in agriculture (Green and Ng'ong'ola 1993; Chaves and Riley 2001; Tadesse and Belay 2004; Asfawa and Admassie 2004; Mercer, et. al., 2005; Iqbal et al., 2006; Zeleke and Bliss, 2010). Evidently, the assessment of factors influencing the adoption of integrated pest management for coffee in Colombia (Chaves and Riley, 2001), the adoption of fertilizer use in Africa (Green and Ng'ong'ola, 1993) and the assessment of factors determining rubber-tea intercropping by the smallholder farmers in Sri Lanka (Iqbal, et., 2006) are worth mentioning. Consistently, we apply the logit model to estimate factors influencing household's decision to grow conservational trees.

A common starting point for logit model is a 'random utility framework', in which the utility of each alternative is a linear function of observed characteristics and the error term of the model (Verbeek 2004,

see also Asfawa and Admassie 2004). Following the context we assumed individuals choose to adopt or not to adopt OFATR depending on their utility maximizing behavior. That is, an individual household can decide to adopt or not to adopt OFATR if he/she expects the adoption will generate him/her the highest possible benefit or utility than else.

Therefore, relying on the frameworks developed by the past studies and following the notation of Wooldridge (2000), the general specification of the logit identifying the probability, P_i , of the i^{th} household's behavior towards the adoption of ecological tree growing technology is given by:

$$P_i = \frac{e^{Z_i}}{1 + e^{Z_i}} \quad 1.1$$

Where Z_i is an indirect utility derived from the adoption decision or random variable that predicts the probability of the i^{th} farmer adopting OFATR. Z_i is also referred to as the log of the odds ratio in favor of the adoption. The odds ratio is defined as the ratio of the probability that a farm household adopts OFATR(P_i) to the probability of non-adoption of OFATR($1 - P_i$).

For an individual farm household, we construct Z_i as a linear function of explanatory variables (X_i s), where β_i is an unknown parameter; X_i is set parameters which influence the i^{th} farm household's adoption decision to grow ecological trees (OFATR). The unknown parameter β_i associated with each X_i is determined by an iterative process that makes use of a maximum likelihood estimate (Wooldridge 2002).

$$Z_i = \ln \left[\frac{P_i}{1 - P_i} \right] = \ln Odds = \beta_0 + \sum \beta_i X_i \quad 1.2$$

Taking natural log in both sides of (1.2), the final standard form of the logistic model estimating the likelihood of adopting OFATR by smallholder households becomes Eq. (1.3). In the Eq. 1.3, i refers to the i^{th} observation in the sample, k refers to number of explanatory variables, β_0 refers to the intercept term, and $\beta_1, \beta_2, \dots, \beta_k$ refer coefficients associated with explanatory variables $X_1, X_2, \dots, X_k$ respectively.

$$Z_i = \ln \left[\frac{P_i}{1 - P_i} \right] = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \dots + \beta_k X_{ki} \quad 1.3$$

Since the parameters β_i s are unbiased and normally distributed, we used an analogue of student's t-test to test the significance of the regression. Throughout the estimation, we use t statistics based on standard errors that are robust to heteroskedasticity. The significances of the coefficients of the variables presented in the logistic model were tested using a log-likelihood ratio assuming a chi-square (χ^2) data distribution (see also Pindyck and Rubinfeld 1981). All the analyses were run using a mix of STATA and Microsoft offices excel program software packages.

Results And Discussions

Characteristics of the respondents

Descriptive statistics of all the variables used in the study are shown in the Table 3. The dependent variable OFATR is a dummy variable that takes the value of 1 if the respondent grows a mix of indigenous species of trees and 0 otherwise. The results for this variable show that about 39.4% (132) of the households surveyed grow conservation trees while 60.6% do not. The study used availability of active labor force (ACLF), gender (GEND), family size (FAMS), and age (AGE) as proxies for demographic characteristics. The size of ACLF in the respondent's family system is a discrete variable representing number of adults who are member of the respondent's household, aged between 15 and 64 years and available for work. The average number of ACLF is about 3.2 adult people with the minimum of 1 and the maximum of 13 implying the ACLF of the majority of the households is less than 4. This might be due to the fact that majority of the younger adults are devoted to traditional weaving and/or migrate to urban areas.

Table 3
Summary of the descriptive statistics of the variables used in the analysis

Variable	Observations	Mean	Std. Dev	Min	Max
OFATR	335	0.394	0.489	0	1
GEND	335	0.113	0.318	0	1
FAMS	335	6.970	2.901	1	17
AGE	335	43.776	10.646	20	75
EDUC-CAT	335	2.501	0.692	1	5
OCCUP	335	0.794	0.405	0	1
ACLF	335	3.155	1.796	1	13
FARMS	335	1.023	1.088	0.013	7.818
YTR	335	0.259	0.439	0	1
TGEXP	335	0.722	0.448	0	1
AVATR	335	0.328	0.470	0	1
TRAIN	335	0.600	0.491	0	1
SULNTR	335	0.138	0.229	0	1.5
HPP	335	0.281	0.449	0	1
HPC	335	0.537	0.499	0	1
IPC	335	0.182	0.386	0	1
Source: Authors' compilations from field survey					

The gender (GEND) status of the respondents is either male or female. It is included to observe the implications of gender differences on conservational decision-makings. From the sampled households 11.3% are female and 88.7% are male. Family size (FAMS) is a discrete variable representing number of people in the household. The average family size is 6.9 people with the minimum of 1 and the maximum of 17. The study proxies human capital of the households by their head's age (AGE), education level (EDUC-CAT) and tree growing experience (TGEXP). The respondent's tree growing experience in the past (TGEXP) is a dummy variable attains a value of 1 for those who have experience and 0 otherwise. Among the respondents, 72.2% have tree growing experience while the rest 27.8% do not. The respondent's age (AGE) is a continuous variable representing age in number of years. The average age of the sample household heads is nearly 43.8 years with the minimum of 20 years to the maximum of 75 year old.

Thus, majority of the household heads are aged on the high side of ages above 40 years. This might be because of the fact that some parents co-reside with son and daughter-in-law and because of age-selective migration of the younger male to urban areas.

The education variable is represented in categorical orders ranging from 1 to 5 with the average of 2.5, which is equivalent to primary school level below grade 8. Average education levels are low because older generations are relatively uneducated than younger generations. As Table 3 indicated, about 25.9% of surveyed households generate liquid cash income through sale of trees while the rest 74.1% do not. Moreover, as a component of socio-economic indicator, the study proxied occupation status of the households by a dummy variable that assume the value of 1 if the respondent household's head work solely on-farms and 0 if work on on-farm and off-farm activities. Accordingly, 20.6% of farm households have an off-farm job while 79.4% exclusively work on-farms. Farm size (FARMS) is a continuous variable with the size of farms in hectares. This variable represents the land owned by household. As shown in the Table 3, the average size of farm or landholding is 1.02 hectares of land and there appears to be a wide range of variability in farmland ownership ranging from 0.01 hectares farm possession at the minimum to owning 7.82 hectares of farmland at the maximum.

The agro-ecological origin of the respondents shows that 28.1% are from HPP zone, 53.7% are from HPC zone, and the rest 18.2% are from LPC zone. Availability of seedling (AVATR) variable suggests that about 32.8% of the respondents have sufficient access to sources of seedlings while the rest 67.2% do lack. The study proxied land suitability for tree growing by number of hectares of the household's land located on sloppy mountains. If the household owns larger hectares of land area on mountainous slopes, the owner has very suitable land area for tree growing than cropping. About 43.9% of the respondents have more than 10% of their own land area on sloppy mountains. Training variable of the study indicate that about 60% of the respondents are either consulted information or received training on land and soil conservation measures while the other 40% do not.

In general, majority of the households surveyed averagely fail to adopt OFATR. Most of those households who did not grow trees are male headed with more than 43 years of age, host more than six people per household, and have less than four working age people in the household. Furthermore, these households on average hold less than 1.02 hectares of land area, attained education status below grade 8, work solely on small-scaled and fragmented farmlands, and have poor access to off-farm economic opportunities. On the other hand, the data also reveal that a household who plant and grow trees have acquired tree growing experiences in the past, use trees mainly for home consumption with low sales for cash, were informed about the importance of trees and owns land area that can primarily be used for tree growing than for crop production and animal grazing. We also observed that there exist old-aged trees in traditionally protected areas of Gamo highlands; funeral and mystical sites are worth mentioning (Fig. 1)

The summaries of descriptive statistics for household who adopt OFATR and household who do not adopt OFATR are separately reported in Appendix 2 and Appendix 3, respectively.

Factors determining the adoption of OFATR by smallholder farm households in the Gamo highland of Southern Ethiopia

In this section, we outline the partial correlation and main results exploring the determinants of conservational tree growing behavior of households specific to Gamo highlands of Southern Ethiopia. Initially partial correlation analysis was performed. This was to assess the inter-relation of the factors that potentially affect the farmer's decision to adopt OFATR. Appendix 1 summarizes partial and semi-partial correlation coefficients of the main factors associated with the decision to adopt conservational tree growing (OFATR) by smallholder farmers in Gamo highlands. Of the factors, six variables are significantly correlated ($P < 0.1$) with the decision to adopt conservational tree growing and results consistent with the logit estimations. These factors are (i) age of the household head (AGE) measured in years, (ii) age-squared of the respondent (AGE^2), (iii) farm size of the household measured in hectares of land area (FARMS), (iv) cash income that households generate through sales of trees or tree goods measured in units of 'birr' value of the sales (YTR), (v) past experience of growing trees proxies by dummy values of existence or non-existence (TGEXP), and (vi) land suitability (SULNTR) for growing trees measured in hectares of land area on mountains or very sloppy location.

Likewise, to assess the relative contribution of significant factors we principally used a multivariate logistic regression analysis. Logistic estimates predicting the maximum likelihood for the factors that determine the adoption of conservational tree growing behavior of farm households are presented in Table 4. The estimates were made with and without controlling for agro-ecological dummies in order for capturing the unobserved factors specific to varying agro-ecologies. The logit estimation also founds significant at 1% level of significance; i.e., the log-likelihood ratio (regression deviance) is significant ($P < 0.01$) throughout the estimations, indicating that the model is statistically valid.

Table 4
Summary of the factors associated with OFATR adoption: The logit estimates

Variables	Coefficients	Robust standard errors	P > /Z/	Coefficients	Robust standard errors	P > /Z/
	Estimation 1(Appendix 4)			Estimation 2 (Appendix 5)		
GEND	-0.769	0.503	0.147	-0.749	0.541	0.166
FAMS	0.026	0.064	0.687	0.004	0.066	0.946
AGE	0.209**	0.103	0.044	0.218**	0.106	0.039
EDUC-CAT	0.050	0.209	0.810	0.042	0.212	0.845
OCCUP	0.239	0.346	0.489	0.284	0.356	0.423
ACLF	0.025	0.103	0.810	0.043	0.107	0.688
FARMS	-0.392***	0.160	0.014	-0.473***	0.175	0.007
YTR	0.612**	0.305	0.045	0.599*	0.308	0.052
TGEXP	4.346***	1.049	0.000	4.507***	1.092	0.000
AVATR	0.169	0.305	0.578	0.146	0.307	0.633
TRAIN	0.403	0.298	0.177	0.349	0.304	0.249
SULNTR	1.785**	0.814	0.028	1.962**	0.895	0.028
AGE ²	-0.002**	0.001	0.052	-0.002*	0.001	0.050
HPP				-0.642	0.428	0.134
HPC				-0.726	0.413	0.079
Constant	-9.849***	2.403	0.000	-9.515***	2.470	0.000
Pseudo R ²	0.286			0.292		
Log likelihood	-160.337			-158.978		
* P < 0.1, ** P < 0.05, and *** P < 0.01						

Source: Authors' computation based on field survey

Based on t-probability values, smallholders' OFATR adoption behavior is positively and significantly associated to household's age (AGE), the existence of tree growing experience (TGEXP), household's capacity to generate cash income from trees (YTR) and the availability of suitable land area for tree growing (SULNTR). However, smallholder OFATR adoption decision is negatively related to the age-squared variable (AGE²) and the farm size available to the households (FARMS).

Among others, past treegrowing experience is the most significant factor associated with tree growing behavior of smallholder farmers in the current Gamo highlands. In other words, households with past tree growing experience are more likely adopt OFATR relative to household without such experience. Evidently, we demonstrate that significant number of farmers who grow trees in the past also plant and grow more number and species of trees in their present farms. This is consistent with the hypothesis we made so far and with the predictions that producers primarily specialize in the agricultural system in which they have past experiences.

The age variable is differently resulted as it was unclearly hypothesized. The estimates indicate that age and age-squared variables remain noteworthy to explain the adoption behavior of households. The age-squared variable was included to assess whether the likelihood of adoption behavior diminishes at some threshold level of age or not. The estimates for this variable suggest that the likelihood of OFATR adoption diminishes meaningfully ($P < 0.1$) as age of the household heads increases, particularly in the Gamo highlands. Thus, on average, conservational tree growing behavior of farm households is positively related to age of household heads but can diminish across age as the AGE^2 variable is negatively related to OFATR ($P < 0.05$). Therefore, there can have some threshold level of age on which household head's tree growing behavior can change from rising trend to diminishing trend. This is consistent with Rogers's (1995) and Sidibe's (2005) estimates of the age influence on the technology adoption behavior of the adopters but inconsistent to justify their conclusions. Rogers (1995) and Sidibe (2005) demonstrate that younger people have a greater chance of acquiring and applying knowledge and skill than older people. This does mean that people can develop experience and skill of doing things across age. However, unlike their argument, the estimates of the TGEXP variable in this study prove strong positive association to OFATR, which is evidently significant.

The availability of suitable land area for tree growing (SULNTR) is positively and significantly ($P < 0.05$) influences OFATR adoption decision of households. Farm household who owns more hectares of land in mountainous area that is suitable for tree growing more likely adopt OFATR relative to households who possess less mountainous land area that is consistent to support our hypothesis. However, the estimates for farm size variable founds paradoxical. It disproves the fixed transaction costs hypothesis that 'the adoption of an innovation will tend to take place earlier and larger on large farms than on small farms' (Feder and O'Mara 1981). The variable also finds inconsistent to our hypothesis that the larger the farm size (FARMS) a farm household owns the more land area can be accessed for planting and growing trees and the more number and species of trees can be planted. We estimate strong negative association between FARMS and OFATR. This supports the conclusion by Bekalo and Banguy (2002) – 'environmentally friendly investment decisions are a luxury for rich but a necessity for poor'.

In contrast, estimates for gender of heading households (GEND), family size of the household (FAMS), and education status of the household head (EDUC-CAT) are inconsistent to support the hypotheses made so far, not significantly influence the variation in OFATR adoption and hence less likely affect OFATR adoption decision of households. Likewise, the estimates for occupation category of the household (OCCUP), access to training and information (TRAIN), availability of seedlings (AVATR), availability of

active working age labor force in the household (ACLF), and agro-ecological differences in the Gamo highlands all showed statistically insignificant associated to OFATR. Thus, these factors are less likely to affect conservational tree growing behavior of smallholder farm households in Gamo highlands.

Specifically, we assumed farmers with formal education (EDUC-CAT) can have greater agricultural awareness than others and this variable is assumed to have positive link to the adoption of OFATR. Unlike the hypothesis, the estimates shows that EDUC-CAT is positively but insignificantly associated with OFATR, this reveal that education is less likely influence conservational tree growing behavior of households in the study area. This is inconsistent with the conclusions by Tassew (2004) and Sidibe (2005). We also observe that households headed by educated people have relatively more number of educated labor forces in their family system than the uneducated one. In view of these, one can expect that more number of skilled labor forces in the family might pave the way for tree growing opportunities. However, the coefficient for EDUC-CAT variable does suggest the reverse. This reminds us the narration by an old man in Chench - "I don't want my child will farm ... as I lived poor because of my farms". If this continues to hold and educated people leave farms before agricultural transformation, the future of rural Ethiopia, mainly for the highlanders, might become dark. These suggest some cautious intervention and necessitate further analysis of the events in the smallholders' agriculture in Gamo highlands.

We expected that female-headedness can negatively influence OFATR adoption because of labor shortages and hypothesized that labor constraints of the family can limit the adoption of conservational tree growing (OFATR). Even if, the estimation results indicate female-headed household are negatively affect OFATR adoption but it is statistically insignificant and hence gender of the household cannot make a big difference in the adoption behavior of households. Similarly, even though the estimation result supports the hypothesis that household with larger number of family size (FAMS) and larger number of working age people (ACLF) in the family system tend to adopt OFATR than households with less family size and less number of active labor in Gamo highlands but these results are also statistically insignificant.

The variations in agro-ecological zones (for example, HPP, HPC and LPC) do not result any significant difference in the OFATR adoption behavior of household. In other words, irrespective of their agro-ecological location, similar factors influence farm households' OFATR adoption decisions. Although we hypothesized that availability of off-farm economic occupation (OCCUP) and OFATR adoption behavior are ambiguous, the model result indicate that having an off-farm job positively affects the likelihood of a farmer's OFATR adoption behavior but it is statistically insignificant and hence we find weak evidence that support the strong association between OCCUP and OFATR adoption.

On the contrary, the cash income that households generate from sales of trees from farms (YTR) meaningfully links to their OFATR adoption behavior. On the one hand, occupational differences that might cause variation on per head income of households founds insignificant to explain difference in the OFATR adoption behavior of households. On the other hand, income that can allow ease access to inputs finds insignificant to explain the variation in OFATR adoption. Therefore, though our estimates for the

YTR variable do support Abera's (2003) study that he reports negative role of off-farm income in the adoption of soil conservation measures in Ethiopia, the path way through which income variable (YTR) links to tree growing behavior of farm households necessitates further scrutiny. This is soundly that availability of seedlings (inputs) also founds less likely to explain OFATR adoption behavior of smallholders in Gamo highlands.

Conclusion And Policy Implications

The study has intended to estimate factors determining the adoption behavior of smallholder farm households towards conservational tree growing specific to Gamo highlands. The results indicated that as age of household heads rise and households get involved in tree growing experiences they tend to plant and grow more number and species of trees, harvest more tree goods, earn more cash income from sales of trees and further adopt planting and growing of more number and species of trees, though it diminishes with age of household heads.

Paradoxically, households with larger resource base (mainly land) do not grow larger number and species of trees as compared to households with smaller resource base. Likewise, smallholder households fail to plant and grow conservational trees or encouraged to plant and grow conservational trees not because of knowledge and information gaps or its perfections, not because of being male or female-headedness, not because of excess or shortage availability of working age people in the household, and not because of insufficient availability or unavailability of seedling inputs but they characterize varying experiences of tree growing in the past, ages of the household head, hectares of land area available to the households and suitability for growing trees than cropping, and cash income generates from sales of trees and tree products.

We also observe that conflicts with adjacent farm household others might influence tree growing behavior of smallholders in Gamo highlands. In addition, we witness that cultural, religious, and old-aged funeral sites can be taken as potential sources for collecting becoming extinct tree species mainly in Gamo highlands of Southern Ethiopia. Thus, indigenous social organizations can serve as potential sources for collecting becoming extinct tree species in the smallholders' agriculture, mainly in Gamo highlands of Southern Ethiopia. These also suggest positive role of indigenous institutions for forestry development, poverty reduction and sustainable development in rural Ethiopia in general and in Gamo highlands in particular. Therefore, we recommend some important respects: (i) revival of shock resilient green economy is timely though late, (ii) except fattening history, dinosaurs can contribute nothing for future, and (iii) resources must regenerate by many as development needs participation of developers and beneficiaries, but still (iv) further inspection must be done for evidence-based interventions.

Abbreviations

CRGE: climate resilient green economy, *OFATR*: conservational tree growing, *FAMS*: family size, *AGE*: household head's age, *GEND*: Gender, *ACLF*: active labor force, *EDUC-CAT*: education, *TGEXP*: tree

growing experience, TRAIN: training, OCCUP: occupation variable, YTR: cash income from tree, OCCUP: off-farm occupations, SULNTR: land suitability for tree growing, FARMS: farm size, AVATR: availability of seedling sources, HPP: high potential perennial agro-ecological zone, HPC: high potential cereal agro-ecological zone, LPC: low potential cereal agro-ecological zone.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data and materials

The data used for this study can be obtained from the corresponding author up on request.

Competing interests

The authors declare that they have no competing interests.

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Authors' Contributions

The corresponding author is the major contributor from administering the data collection to writing the draft manuscript, the co-author contributed by administering the survey and editing the manuscript.

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Figures



Figure 1

Traditionally protected trees in Nagasa of Chench

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