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Devolution and Sustainable Management of Forests in Developing Countries

Quasi-experimental Evidence from Household Level Data in Ethiopia

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Abstract

This research aims to evaluate the role that devolution of forest tenure rights plays in the sustainable management of forests in developing countries at a highly disaggregated level, using data from a sample of 600 households in four major regions of Ethiopia. Specifically, the study investigates the impacts of the devolution of forest tenure rights towards local communities on forest quality and livelihoods empirically, employing a quasi-experimental approach comparing households that are members of forest user groups (FUGs) and households that are not. The study uses four outcome variables as measurable indicators to empirically analyze the impacts of the devolution and its contributions to improvements in the livelihoods of forest dwellers. The results suggest that FUGs had a robust and positive impact on the harvest of various forest products. These findings contribute to the literature on devolution and highlight implications for research, policy, and development practice with respect to forest commons.

Keywords: institutions; common property forest management; matching; inverse probability weights; Ethiopia

JEL: Q23, Q54

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ABSTRACT

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1. Introduction

Around a third of the world's total landmass, i.e., about 4 billion hectares, is covered by forests. However, roughly three quarters of the world's forests still fall under government control (FAO, 2010a; RRI and ITTO, 2010; FAO 2020). Devolution[1] of forest tenure rights to local communities is suggested as a means to achieve sustainable forest management and livelihoods, owing to the inadequacies and often dismal outcomes associated with state-centric forest management (Agrawal et al., 2008; Gobeze et al., 2009; Tucker, 2010). As a result, over the past few decades and especially since the 1990s, there has been an increasing trend in devolving forest tenure rights towards local community control in a number of countries in the tropics (Sunderlin et al., 2008; Larson et al., 2010). For example, it is believed that about half a billion hectares of forest land have been transferred from state to community control (White and Martin, 2002; USAID, 2012). Forests also constitute an important part of common property resources (CPRs) around the world. CPRs are resources suited for joint-use arrangements, i.e., for common-property regimes (McKean, 2000).

The role of formal and informal institutions[2] in natural resource management has attracted attention (e.g., Ostrom 1990; North 1990; Agrawal 2001a, 2001b; Stern 2011). Common property theory postulates that successful CPR management depends to a great extent on the rules and regulations governing individual behavior that are applied and practiced in the management of these resources (Ostrom 1990; Proteete et al. 2010; Tucker 2010). Empirical research on the issue has focused on broad principles of institutional design (Ostrom 1999); the need for compatibility between institutions and their political-ecological context (Ribot 1999; Dietz et al. 2003; Hayes and Ostrom 2005; Ostrom and Nagendra 2006); the nature of institutional mediation (Agrawal and Yadama 1997); the importance of local enforcement (Agrawal 2005; Gibson et al. 2005; Coleman and Steed 2009); the necessity of broad-based participation in institutionalized governance (Ribot 2002); the relationship between indigenous people and forests (Rangan and Lane 2001); size (Agrawal and Goyel 2001); and the role of local variation or contexts in shaping resource-related outcomes (Agrawal and Chhatre 2006).

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[1] Here, following Agrawal and Ribot (1999), 'devolution' means an act of decentralization and deconcentration in which a central government formally cedes forest governance powers to lower level actors and institutions in a political-administrative and territorial hierarchy.

[2] Institutions / economic institutions are a set of rules or norms that specify certain forms of action as permissible but others as forbidden, and provide for certain penalties and defence when violations occur (North 1981; Runge, 1984). In this paper, the term is used to mean formal or informal local arrangements (organizations and rules) that are put in place to govern resources such as forests.

However, as can be seen, much of the literature in this regard has mainly focused on the governance aspect of the devolution and decentralized management of forests, i.e., whether credible full devolution exists (e.g. Lynch 1998, Agrawal and Ribot 1999, Bruce 1999, Lindsay 2004, Agrawal and Gupta 2005, Mustalahti and Lund 2010, Chomba et al 2015, Chinangwa et al 2016, Mutune and Lund 2016, Mollick et al 2018, Das 2019, Magessa et al 2020; Agrawal et al 2023). In addition, the strand of research on commons over the recent decade seems to have focused on effective monitoring by means of various methods (Takayama and Nakatani 2014; Rasolofoson et al 2015; Oldekop et al 2019; Scheliecher et al 2020 Wiik et al 2020; Christensen et al 2021; Eisenbarth et al 2021; Barrett 2021). However, the effectiveness of devolution of forest tenure rights towards local communities has not been thoroughly investigated. Previous studies that looked into the impacts of forestry sector tenure reform or decentralization on forest conditions and livelihoods also provide mixed results (Lambrick et al 2014, Lund et al 2018, Senganimalunje et al 2015). Furthermore, there is a dearth of empirical evidence about the link between forest decentralization and poverty alleviation, i.e., its impact on livelihoods (Adam and Eltayeb 2016). There also appears to be a dearth of data pertaining to the impact of forest decentralization on local human welfare indicators (Bowler et al 2012).

Therefore, the aim of this research is to enhance informed policy-making by evaluating the role of the devolution of forest tenure rights to local communities in sustainable forest management in developing countries at a highly disaggregated level, i.e., at the household level. The study takes Ethiopia as a case in point and uses data collected in 2013 from a sample of 600 households drawn from four major regions of Ethiopia. More specifically, the objectives of this study are: (i.) to empirically analyze the important determinants of participation in forest collective action; and (ii.) to analyze the effects of the devolution of ownership and control of forests to local communities on the condition of the forests and the livelihoods of forest-based households. Key questions include: Does the devolution of forest tenure rights to local communities have any effect on the sustainable management of forest commons? What is the impact of the devolution of forest tenure rights to local communities on forest dwellers, and how has it affected their livelihoods? What are the most important determinants of household participation in forest commons?

In Ethiopia, notwithstanding the importance of understanding the role of institutions and property rights regimes in forest management, the empirical evidence is still very limited, although it is increasing (e.g., see Mekonnen 2009; Beyene et al., 2016; Beyene and Koch 2013; Gebreegziabher et al., 2011a). Property rights in Ethiopian rural areas are often very weak, particularly with respect to common forest and grazing lands (Mekonnen and Bluffstone 2008). Specifically, empirical evidence on the impacts of the devolution of forest tenure rights towards local communities on forest quality and the livelihoods of forest-dwellers, as well as the drivers of success, is scant or mixed. In addition, earlier work in Ethiopia and elsewhere has concentrated on community-level data (Gebremedhin et al., 2003; Gebreegziabher et al., 2021). Thus, it would be useful to broaden our understanding of the impacts of this devolution on forest quality and livelihoods by providing insights from disaggregated household-level data.

This research contributes to the literature firstly by empirically validating some of the most prominent views (theoretical conjectures), particularly in the commons literature. Second, at the policy level, it provides insights into the factors that make local CPR institutions successful and how to improve outcomes, based on household level data. In so doing, the research sheds light on some of the important issues associated with managing common property resources.

The rest of the paper is organized as follows: The next section presents the study context. Section 3 discusses the conceptual framework. Section 4 provides an overview of the empirical strategy and data. Section 5 presents results and discussion. Section 6 draws conclusions.

2. Study Context

Forest landscape, i.e., natural forests, constitutes around 16 percent of Ethiopia's 1.1 million square kilometers of total landmass.

Historically, tenure or property rights to land, particularly agricultural land, in Ethiopia were vested in the *rist* system, the *gult* system of private land holding, or the church. The *rist* system was the dominant form of land tenure in the northern part of the country before the 1975 land reforms. This was a communal / clan-based form of land tenure in which the right to land was not exclusive, but shared. Specifically, an individual had usufruct rights (*rist* rights) to land in a given community only if s/he was able to establish a direct line of descent from the recognized original holder of the land (Gebreegziabher et al 2011a). The *gult* system was characterized by absentee owners, as it was the royal kinsmen/women who held the *gult* holdings (Hussein, 2004). However, both of these systems of land tenure were abolished with the 1975 radical land reforms (i.e., Proclamation No. 31, 1975) which nationalized all the land into state hands (Nickola, 1988; Stellmacher 2007). In the past, during the Imperial regimes specifically and the Derg regime in particular, forests or forestlands were under the exclusive control of the state (Dessalegn, 2001; Eshetu, 2014), which served to exclude communities from participation and denied their historic usage rights. This led to *de facto* open access conditions and illegal, unsustainable utilization of the forests. Outcomes were often dismal due to the inadequacies associated with state-centric forest management and the lack of a sense of ownership among forest-dwelling communities. Hence, the process of PFM (participatory forest management), also known as CFM (community forest management) or CBFM (community-based forest management), was initiated in Ethiopia as a way of enhancing a sense of ownership and, consequently, more sustainable management of forests. The major PFM intervention sites in Ethiopia have been located in Oromia and SNNP (Mekonnen and Bluffstone 2015).

Various stakeholders, including both Government and NGOs, have been involved in the initiation and implementation of PFM in Ethiopia. For example, organizations such as GIZ, FARM-Africa / SOS-Sahel, the Japan International Cooperation Agency (JICA), the Non-Timber Forest Products Research and Development Project, the Ethiopian Forest Coffee Forum, Oromia Forest and Wildlife Enterprise, and Regional Cooperative Offices were key proponents of PFM.

Although collective action, particularly in the realms of irrigation water and grazing land management, has been an indigenous tradition for centuries (Gebreegziabher, 1999; Gebreegziabher *et al*., 2011b), the PFM approach was first introduced in Ethiopia around thirty years ago (Negassa, 2007). However, the actual decentralization (transfer of rights) and devolution of forest land to local communities started in June 2000. The experiences and lessons gleaned from the implementation of PFM contribute not only to the development of the country's forest policy and regional forest management strategies, but also to the devolution thrust. In addition, exchange visits between various PFM sites have also taken place, enabling different communities to learn from each other and observe changes to the forest. Most of the country's natural forests are located in the Oromia region, where roughly 1.6 million hectares of natural forests are currently under community management. The Sokora Forest Management Association was the first official FUG to sign an agreement with the government. Thus far, the devolution process has had over twenty years of practical implementation. Consequently, many FUGs are active in Ethiopia today, with around 700 in Oromia alone. In addition, some FUGs, also known as WAJIB (Waldayaa Jiraatoota Bosonaa) in *Afan Oromo*[3], are growing into cooperatives and cooperative union levels (Veerakumaran and Negussie 2007).

Hence, it would be highly relevant for policy-makers to understand the actual situation on the ground, namely to what extent, if any, the devolution of forest management rights has contributed to an enhancement in forest quality and the livelihoods of forest-dwellers. Ethiopia's CRGE (Climate Resilient Green Economy) strategy also envisages protecting and re-establishing forests to align with their economic and ecosystem services, including as carbon sinks. Therefore, this research could contribute towards supporting this CRGE strategy, as well as Ethiopia's LT-LEDS (Long-Term Low Emission and Climate Resilient Strategy). With respect to these programs, the Ministry of Environment, Forest and Climate Change (MoEFCC) seeks to reduce forestry emissions, which were about 65Mt in 2020. The Ministry also sought to sustainably protect, maintain and utilize about 2 million ha of forest through PFM by 2020 (MoEF, 2015).

3. Conceptual Framework

This section outlines the conceptual framework employed by the study in the empirical analysis (see Fig 1). The study draws on the commons theory (Ostrom, 2009; Ostrom, 2010a). In particular, it builds on insights from Elinor Ostrom's general framework for analyzing the sustainability of **social-ecological systems** (**SES**). Ostrom argued that all resources used by people are embedded in complex social-ecological systems, and identified eight core subsystems that have been observed to affect the management, organization and sustainability of SESs**.** These include the social, economic, and political settings; resource system; resource units; users; governance systems; interactions; outcomes; and related ecosystems.

In the context of this study, the resource system is forests (community forestry), the resource units are forest products such as grasses and fuelwood, the users are FUGs, and the

[3] In the local language of the Oromia region where part of the data comes from, the term translates as Forest Dwellers Association,

governance systems are the institutions that govern the management and utilization of the harvest from community forests (e.g., organization and rules).

As can be seen from Fig 1, the economic system is nested within broader, interconnected, social and ecological systems. The conceptual framework also suggests a two-way link between success (sustainable management) and these broader economic-social-ecological systems. Considered as relatively separable, the resource system, resource units, users and governance system interact to produce outcomes at the SES level, which in turn feedback to affect these subsystems and their components, as well as other larger or smaller SESs. The study measures and defines sustainable management in terms of improvement in forest-based livelihoods and forest quality. Of these eight core subsystems, (1) the users, (2) the resource units, and (3) the governance system are of greatest interest to us.

With respect to users, Ostrom (2010a) also distinguishes between structural variables and core relationships that affect the likelihood of collective action. The structural variables include: the number of participants involved; whether benefits are subtractive or fully shared; the heterogeneity of the participants; face-to-face communication; repetition of interactions; information about past actions; how individuals are linked; and whether individuals are able to enter and exit voluntarily. The core relationships are reputation, trust, and reciprocity and their effect on cooperation. Ostrom especially emphasized the need to establish a link between the structural variables and the core relationships. The literature also emphasizes that better coordinated communities have better managed forests and less open access. In addition, as suggested in the literature [e.g., see Ostrom (1990; 2000; 2009; 2010b), Shyamsundar (2008), Bluffstone et al. (2008); Agrawal (2001) and Agrawal et al. (2008)], fairness, clarity, and appropriate sanctions are also key components of successful sustainable management of forest commons.

4. Empirical Strategy and Data

4.1 Econometric model

The study employs a logistic regression model to empirically analyze the determinants of household participation in FUGs. Hence, assuming a logistic distribution function, the logit model is specified as:

$$\text{prob}\ (y_i = 1) = \frac{e^{x'\beta_i}}{1+e^{x'\beta_i}}$$

and prob (y_i = 0) = $1 - \frac{e^{x'\beta_i}}{1+e^{x'\beta_i}}$. (1)

Note that our interest includes evaluating the impact of membership in FUGs on forest quality and livelihoods. The two most common sources of bias in such an estimation setting are self-selection into the program and measurement bias. Hence, we develop a treatment effect estimation framework that adequately addresses these biases (Imbens and Angrist, 1994; Angrist, Imbens and Rubin, 1996; Heckman, 1997).

Using Eq (1), suppose that, for an individual i, we have two outcomes defined as y_{1i} and y_{0i} that correspond to the outcome with and without treatment, respectively. Hence, by defining m_i as a binary variable indicating treatment (i.e., membership in FUGs) and denoting x_i as a vector of covariates representing the characteristics of individual i, our model for the average treatment effect on the treated individual (ATT) can be specified as (Verbeek, 2008; Wooldridge, 2002):

$$ATT = E[(y_{1i} - y_{0i}) | x_i, m_i = 1]. \quad (2)$$

Eq (2) suggests that the ATT can be consistently estimated as a difference in means between the expected treatment outcome for the treated members ($y1$) and the treatment outcome for the untreated members ($y0$), given covariates x and that the individual received the treatment (i.e., m=1). Note that $y1$ and $y0$ could also be viewed as potential outcomes for the same individual, whereby $y1$ represents the counterfactual in which the individual receives treatment and $y0$ represents the counterfactual situation where the individual does not.

In contexts where there are multiple outcomes to be measured or evaluated, Eq (2) can be extended and specified in a more general form as:

$$ATT_j = E[(y_{1ij} - y_{0ij}) | x_i, m_i = 1], \text{ with } j = F, G, N, T \quad (3)$$

where j stands for the outcome variable of interest to be measured, with F, G, N, and T denoting fuelwood, grass, other NTFP, and total or aggregate forest products, respectively.

According to Rosenbaum and Rubin (1983), the above formulation can be estimated using a propensity score matching (PSM) approach. In this regard, the strategy involves estimating the propensity scores, estimating response differences for pairs matched on the basis of the estimated propensity scores, and then averaging out across all such pairs. Therefore, subjects with similar propensity scores are essentially regarded as a match (Wooldridge, 2002).

The **propensity scores** are estimated by modeling *p(x)≡P(m=1|x)*, which is the probability of treatment given the covariates. As described, matching can be performed conditional on *p(x)* alone rather than on *x*. If outcomes without the intervention are independent of participation given *x*, then they are also independent of participation given *p(x)*. This approach also reduces the multidimensional matching problem into a single-dimensional problem (Rosenbaum and Rubin 1983). Specifically, we use three alternative matching algorithms, i.e., caliper matching[4], nearest-neighbor matching (NNM)[5], and inverse probability weights (IPW) to estimate the treatment effects.

Note that the logit model[6] [see Eq (1) above] also estimates propensity scores using a composite of pre-intervention characteristics of the sampled households, with matching then performed using the propensity scores of each observation. In the estimation of the propensity score, we ignore the effects of covariates (independent variables), since the purpose of our work is to assess the impact of FUGs on outcome variables. However, the choice of covariates to be included in the first step (propensity score estimation) is an issue. Heckman et al. (1997), and Dehejia and Wahba (1999; 2002), argue that omitting important variables can increase the bias in the resulting estimation. Only variables that simultaneously influence the participation decision and outcome variable should be included (Caliendo and Kopeinig, 2008). Nonetheless, there is no deterministic way of deciding which covariates to include (Ho et al, 2007). Estimation of the logit model considers the participation or treatment variable *m* as the dependent variable, which takes the value 1 if a household is member of FUGs, and 0 otherwise.

Another issue of empirical interest is analyzing the effects or impacts of the devolution on forest condition or quality. We consider three indicators of forest outcome as outcome or dependent variables, based on an assessment of FUG-member and non-FUG-member households. These are: i) individual household assessments of the land cover (biomass) of the

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[4] Caliper matching pairs treatment and control groups within a specified distance of their propensity scores. The distance, or caliper width, is usually a fraction of the standard deviation of the propensity scores.

[5] In NNM, each treated observation is matched with an observation in the control group that exhibits the closest propensity score. After matching, the difference between their scores is calculated as the average effect of FUG membership (ATT).

[6] The logistic distribution has a somewhat similar shape to the normal distribution. However, in our case, the logistic distribution is preferred because it has heavier tails, which often increases the robustness of parameter estimates based on it as compared to using the normal distribution (Greene, 2011).

forest; ii) diversity of the tree species of the forest; and iii) use of the forest for protection of wildlife. Since our dependent variables are measured based on a scale ranking of 1-5, with 1 corresponding to the lowest ranked response and 5 corresponding to the highest, we employ an ordered logit model.

4.2 Variables and hypothesis

Three sets of explanatory variables are of primary interest to us, namely: (1) resource characteristics; (2) characteristics of the user; and, (3) the governance regime. In the context of Ethiopia, factors related to the resource characteristics, resource units or products harvested from forest commons include grasses, fuelwood, honey, spices, forest coffee, etc. In addition, the following factors are also considered important determinants of collective action and its effectiveness in the management of communally managed forests: member or user characteristics (which can either facilitate or hinder trust and cooperation); the importance of the resource for livelihood; the types of choices available (which can raise or lower the opportunity cost of cooperation, using variables like distance from the nearest urban market and main road, or development post); infrastructure availability (such as access to credit and extension advice), individual characteristics (such as trust in other people); number of years as a FUG member (which indicates experience participating in community forests and managing the resources); governance and institutional design features (such as the availability of free entry and exit, or whether the household was penalized); the external environment (through the effect of the involvement of external organizations and programs); and members efforts. Membership of the household in one or more FUGs is both the treatment variable and the outcome variable of the participation decision.

The study uses four variables related to the quantity or value of forest products harvested as outcome variables to measure the impact on livelihoods. Specifically, the study considers the following as measurable indicators of forest quality: i) the quantity of fuelwood harvested; ii) the value of the grass (thatch, fodder and handicraft) harvested; iii) the value of other NTFPs (non-timber forest products) harvested (such as coffee, spices and honey); and iv) the aggregate value of all forest products harvested.

With regards the impact of the devolution on forest quality, the study considers three indicators of forest outcome based on beneficiary assessments: (i) land cover (biomass) of the forest; (ii) the diversity of tree species of the forest; and (iii) use of the forest for protection of wildlife. A scale ranking of 1-5 is utilized for our dependent variables, where 1 corresponds to a response of the lowest rank and 5 corresponds to the highest. The study uses these rankings as indicators of impact or quality, because, in our view, local perceptions of impacts and satisfaction reflect the reality on the ground, and beneficiary communities are the ideal witnesses of the extent to which management devolution has impacted on forest quality (Gibson et al 2005; Hayes and Ostrom 2005). These variables are captured as the state of the forest currently (i.e., during the survey period) and over the previous five years. However, the study only uses the current state of the forest for the analysis.

Obviously, benefit and cost considerations are involved in a household's decision to participate in FUGs. The fact that households choose to participate in FUGs creates a number of potential confounders which may affect treatment status. Therefore, we need to control for these confounders. To do so, we use data from non-FUG-member households to develop a counterfactual control group, and then use matching to estimate what would have happened to the four outcome variables in the absence of FUGs.

These confounding variables may cause bias in the ATT estimates (Heinrich et al., 2010), thus controlling for them in the matching process is crucial. Accordingly, the analysis tries to minimize problems caused by selection and omitted variables bias by identifying the best possible matches between FUG-member and non-FUG-member households. In this regard, three sets of factors related to the individual characteristics of users were identified as important potential confounders that may bias the ATT estimates, namely access to infrastructure, district level fixed effects, and institutions or governance regimes. Appendix Table A1 provides details about the definition and measurement of all the variables considered in the study.

The study assumes that forest quality in natural and plantation forests is likely affected not only by institutional elements such as rules and norms, which the study considers as important, but also by community and ecological attributes (Chaiyo et al., 2011). Hence, several other variables are included, as listed in Table A1. The study also assumes that indigenous institutions and social coordination in forest commons in Ethiopia evolved locally in response to circumstances (Agrawal et al., 2008; Jodha, 2008). It also considers and treats social capital as an asset held at the individual level (Glaeser et al 2002), not at the community level as Bowles and Gintis (2002) suggest.

Social coordination can be captured at the household level (Bluffstone et al 2015). Hence, the distance from households to the nearest roads is a critical measure of transport costs and market access, and is thus potentially also a confounder. Because households within villages communally own the forests, the study assumes that they have equal access to products per capita and products per hectare or year in the community forests. The study also assumes that households extract forest products from these forest commons subject to the governance rules and/or norms in place.

Physical isolation is expected to be associated with less extraction by villagers, due to increased transport costs and reduced market opportunities (Hyde et al, 1996; Gallup et al, 1999). This, in turn, should result in better forest quality, i.e., more biomass or greater diversity of species. It is also possible that more isolated villages have systematically different levels of social coordination than less isolated villages, potentially making isolation a confounding factor. Because the distance to roads can vary widely within a village, this variable is measured at the household level.

The study also considered and included district level fixed effects in order to capture differences or attributes not captured in the estimation exercise.

4.3 Survey design and sampling

We use multi-stage stratified random sampling to select our sample. A total of 23 community forests were selected such that they represent the diversity of populations, forest cover, and social and ecological systems. That is, initially, sample study sites or community forests of interest were selected. The criteria considered in selecting the sample site included: (i) diversity in the site's year of establishment; (ii) product diversity; (iii) diversity in terms of whether it was initiated by government, the community or an NGO; and (iv) purpose of establishment. Criterion iv) is particularly relevant in cases where the community forests appeared to be similar with respect to some or most of the previous criteria. Our sample sites were also selected to represent the relative forest cover by region (50% Oromia, 30% SNNP, and 20% Amhara + Tigrai), and to include eight districts (Anderacha, Delomenna, Fageta Lekome, Gimbo, Gobba, Kolla Tembien, Konta and Omo Nada).

From these 23 communities, a sample of 600 households was randomly drawn. Sample households include both FUG members and non-members within the same village. Lists of FUG members and non-members were obtained from the *got* or village administration, and sample respondents were randomly selected from the list.

A detailed survey instrument was developed to collect the relevant data, that includes: socio-economic characteristics of users (households), including household composition and characteristics, human and social capital, household assets, and ownership of and income from livestock or poultry; biophysical attributes of the resource (community forest), such as forest cover or biomass, species diversity, types and quantities of benefits (harvests) from community forests; and institutions and governance, including forest institutions and governance systems. Thirty fieldworkers were recruited and trained to conduct the data collection. In addition, the questionnaire was pre-tested in community forests near Addis Ababa before it was presented to the respondents.

4.4 Data and descriptive statistics

Table 1 presents overall summary statistics of the variables included in our econometric / empirical analyses, and a comparison of FUG-members and non-members in relation to these variables of interest. Also provided in the table are p-values of two-sample t-tests. We observe clear differences between FUG-members and non-members insofar as the outcome variables are concerned. Note that in order to support our econometric analysis, we also use individual household assessments of forest condition on a 1-5 scale ranking as indicators of forest outcome. This is particularly important when considering those dimensions of forest quality for which we don't have measurements. Among these variables, land cover (biomass) of the forest and the use of the forest for the protection of wildlife receive the highest ranks of all the individual household assessment variables considered, while diversity of forest tree species receives a slightly lower rank by comparison. We also find that there is no statistically significant difference between FUG-members and non-members in their assessment of forest condition, which gives more credence to the results.

Considering household characteristics, around 90% of sample households are headed by males. The ages of household heads range between 18 and 103 years, with an average age of 46. Almost 60% of household heads can read and write. Most respondents do not trust people in general. Extension workers have visited beneficiary farmers between 0 and 300 times during the previous 5 years, with an average of 29 visits. As a measure of a household's physical capital endowment, we take the number of livestock owned, measured in tropical livestock units (TLU). Sample households have, on average, 5.4 TLU.

Regarding access to infrastructure, households who live in the study areas walk for over 2 hours on average to reach the nearest town and market. They also walk for an average of 23 minutes to obtain potable water for household use. The majority of sample households (80%) were drawn from Oromia and SNNP, with the remaining 20% located in Amhara and Tigrai. Around two-thirds of FUG-members have rules that allow for free entry to and exit from their groups. Roughly a quarter of sample respondents participate in off-farm wage employment, at an average wage rate of about 30 birr per day.

Regarding access to infrastructure, most of the community forests are within a 42 to 100 minute walk from the Peasant Association (PA), main road, nearest town and nearest market. Most of the communities have access to piped water, but have limited access to microfinance services and electricity.

Two-sample t-tests were used to determine whether or not significant differences between FUG-member and non-member households exist, particularly in relation to potential confounders that may affect treatment status (Rosenbaum and Rubin 1985). The two-sample t-test results show no significant differences between the two categories in most of the key characteristics considered. However, significant differences are found in relation to distance from all-weather roads, membership in farmers' cooperatives, access to credit, and the attributes of governance or institutions.

5. Results and Discussion

5.1 Decision to participate in FUGs

One of the key questions that the study addresses is: what determines participation in FUGs? We employ a logit model to analyze the determinants of participation, predict the probability of participation, and estimate the propensity scores. Table 2 presents the logit model regression results of the determinants of the participation decision. As can be seen from the table, the important factors underlying a household's decision to participate in FUGs are: distance to main road; trust in people; number of years as a FUG member; district dummies; and governance and institutional design features, such as whether members can enter and exit freely.

Among the variables related to access to infrastructure, 'distance to main road' negatively and significantly influenced household's participation in FUGs, whereas 'distance to market' appeared to positively influence households' participation in FUGs. In areas that are more distant from markets, opportunities for off-farm and other sources of livelihood diversification tend to be limited, increasing the value of participation in FUGs for households. Among the variables related to individual characteristics, 'trust in people' positively and significantly influenced participation, whereas 'number of years as a beneficiary of forests' negatively and significantly influenced participation. Perhaps the longer households stay in a forest, the more old age and related factors might discourage or hinder participation.

Governance or institutional factors, such as the ability of members to enter and exit freely, also positively and significantly influenced the participation decision, suggesting that democratic rules are an important factor. Among the district dummies, Fageta Lekoma and Gobba turned out to be significant and positive, whereas Omo Nada and Konta turned out to be significant and negative. This suggests that households in Fageta Lekoma and Gobba tend to be more likely to participate in FUGs compared to those in Gimbo. On the other hand, households in Omo Nada and Konta tend to be less likely to participate in FUGs compared to those in Gimbo. Perhaps, because the importance of the resource to the community varies between districts, households in some districts are less willing to participate in FUGs than others. Table 2 also presents the marginal effect of the explanatory variables on the probability of participation (see columns 3 & 4, Table 2).

5.2 Estimation results of the effect of FUGs on forest outcomes

This section presents the matching estimation results of the effect of FUGs on forest outcomes. As noted above, the study uses four outcome variables as indicators of forest outcome or quality: i) quantity of fuelwood harvested; ii) value of grass harvested; iii) value of other NTFPs harvested; and iv) (aggregate) value of all forest products harvested. The study uses data from non-FUG-member households to develop a counterfactual control group, and then employs matching to estimate these outcome variables in the absence of FUGs.

Before proceeding, it is important to check or test the quality of matching, including the first steps of the estimation (propensity score, common support). Hence, the study uses a two-sample t-test to check if there are significant differences in covariate means between the treated and control groups. The study also tests for overlap and common support. Accordingly, the results show no significant differences between the treatment and control groups in relation to the covariates of interest. Moreover, the results also show that the overlap[7] and common support assumptions are not violated. Figures A1 and A2 in the appendices provide the densities of the probability of attaining each treatment level of the subject that were used in our matching procedure.

Table 3 presents the estimation results of the ATT of FUG membership from three alternative matching methods, namely: caliper matching, nearest-neighbor matching (NNM)[8], and inverse probability weights (IPW). The results confirm a difference between FUG-members and non-members in terms of the quantity of fuelwood harvested per year. The results indicate the existence of a significant positive addition or gain for FUG members, after controlling for other characteristics. On average, FUG members harvest 1,500 kg more fuelwood per year than non-members. These results are robust with respect to the alternative matching algorithms employed.

Table 4 presents the ATTs from the three matching methods for the outcome variable 'value of grass harvest'. However, as can be seen from the table, although the NNM results show a statistically significant difference, the caliper and IPW matching results do not. This indicates that there is no significant difference between the two groups, after controlling for other characteristics. This could be because grass harvest is not as important a product compared to the others.

Table 5 presents the ATTs from the three matching methods for the outcome variable of other NTFPs (i.e., coffee, spices and honey). The results confirm statistically significant differences between FUG members and non-members. On average, FUG members harvest NTFPs worth around 1,500 birr (US$80.08) more per year than non- members. The results are robust with respect to the alternative matching algorithms employed.

[7] One of the assumptions required to use the treatment effects estimators is the overlap assumption, which states that each individual has a positive probability of receiving each treatment level.

[8] NNM imputes the missing potential outcome for each subject by using an average of the outcomes of similar subjects that receive the other treatment level. Similarity between subjects is based on a weighted function of the covariates for each observation. The ATT is computed by taking the average of the difference between the observed and imputed potential outcomes for each subject.

Table 6 offers the ATTs from the three matching methods for the outcome variable 'aggregate value of all forest products harvest'. The results confirm a difference between FUG members and non-members, indicating that, on average, FUGs members harvest forest products worth around 3,000 birr (US$ 160.17) more per year than non-members. The results are once again robust with respect to the alternative matching algorithms employed.

5.3 Assessment determinants of forest user groups members and non-members

Analyzing the effects of devolution on forest condition or quality is one of the key objectives of this study. However, because we do not carry out any forest measurements, we use individual household assessments or perceptions of forest condition as indicators of forest quality. Our descriptive results confirm no significant statistical difference between the assessments made by FUG members and non-members, suggesting the absence of gratification bias in their assessments. The study evaluates three indicators of forest outcome based on beneficiary household assessments as outcome or dependent variables: 1) individual household assessments of the land cover (biomass) of the forest; 2) diversity of tree species of the forest; and 3) use of the forest as protection for wildlife. In general, in terms of these three outcome indicators, the household assessments or perceptions of the forest condition are above average. The study employs an ordered logit model, as the dependent variables are measured based on a 1-5 scale ranking, where 1 indicates a response corresponding to the lowest rank, and 5 the highest.

The study considered four sets of variables as right-hand-side or explanatory variables. These include: (i) household and household head characteristics (gender, age, marital status, main activity), individual characteristics (membership in FUGs, membership in farmers' associations, trust in people, number of years as a FUG member), wealth or livestock in TLU, and participation in off-farm employment; (ii) access to infrastructure (distance to main road, distance to nearest marketplace, credit access, access to extension advice); (iii) district dummies; and (iv) the governance regime, i.e., governance or institutional design features (whether members can enter and exit freely, and whether the household was penalized). The study performed ordered logit model regressions for the three outcome indicators. Results are provided in Table 7.

With regard to household assessments of the land cover of the forest, individual characteristics, such as membership in FUGs, membership in farmers' associations, and number of years as a member of FUGs turned out to be the most important factors. All variables except membership in FUGs were negatively associated with the assessment of land cover or biomass of the forest for both FUG members and non-members. With regards access to infrastructure: distance to main road, distance to nearest market, number of extension visits, and access to credit turned out to be the most important factors, with all variables except 'distance to nearest market' showing a significant negative association. All the district dummies except Gobba turned out to be significant and positive vis-à-vis Gimbo. Perhaps this is because the biomass or intensity of the forest is far better in those districts than in Gimbo. Among the governance or institutional design features, 'whether the household was penalized' turned out to have a significant positive association. This appears to be consistent with the notion that the temptation to break the rules increases when the forest is in relatively better condition. That is, when the expected benefits resulting from breaking the rules are greater than the expected costs (Janssen et al, 2013).

With regards the assessments or perceptions of species diversity in the forest: Of the variables related to individual characteristics of the head of the household, 'membership in FUGs' and 'membership in farmers' associations' turned out to be most significant factors. Membership in FUGs had a significant positive association, whereas membership in farmers' associations had a significant negative association. Of the access to infrastructure variables, 'distance to main road', 'distance to nearest market', and 'number of extension visits' turned out to be the most important factors, with all but 'distance to the nearest market' showing a significant negative association. All the district dummies except Fageta Lekoma also turned out to have a significant positive association vis-à-vis Gimbo. Among the governance or institutional design features, whether members can enter and exit freely also had a significant positive impact on a household's assessment or perception of species diversity of the forest, suggesting the importance of democratic rules.

With respect to the wildlife protection outcome variable: Of the variables related to individual characteristics of the head of the household, 'membership in FUGs' turned out to be the most influential factor, significantly and positively associated with households' assessments. All the district dummies turned out to have a significant positive association. The average household in all the districts appears to have a positive assessment of the use of the forest for wildlife protection vis-à-vis Gimbo. Of the governance or institutional design feature variables, 'whether members can enter and exit freely' also positively and significantly influenced a household's assessment or perception of the use of the forest for wildlife protection, again suggesting the importance of democratic rules. This result is, to an extent, similar to the results for the assessment or perception of species diversity of the forest.

We also present the marginal effects of the explanatory variables on the probabilities of very high or very low outcomes of the dependent variables (see Table 8).

6. Conclusions and Implications

About three quarters of the world's forests still fall under government control. Owing to the inadequacies and often dismal outcomes associated with state-centric forest management, the devolution of forest tenure rights to local communities has been suggested as a means to achieve sustainable forest management and livelihoods. As a result, the trend of devolving forest tenure rights towards local community control has increased in a number of countries in the tropics over the past few decades, and especially since the 1990s. It would be of interest to broaden our understanding of the extent to which this process has been a success, or not. This research evaluates the role of the devolution of forest tenure rights on the sustainable management of forests in developing countries at a highly disaggregated level, i.e., using household level data, and taking Ethiopia as a case in point. It also investigates the determinants of the household's decision to participate in FUGs (to whom forest tenure rights typically devolve). The following conclusions can be drawn:

First, concerning the determinants of participation in FUGs, the most important factors for households appear to be: access to infrastructure, such as the distance to the main road; individual characteristics such as trust in people and number of years as a FUG member; district level fixed effects; and governance or institutional design features, such as whether members can enter and exit freely.

Second, concerning the impacts of the devolution, the findings suggest a statistically significant difference between FUG members and non-members in terms of the harvests of various forest products per year. The findings suggest gains with respect to both quantity and value for FUG member households, after controlling for other characteristics. On average, per year, FUG members harvest 1,500 kg more fuelwood, other NTFPs worth around about 1,500 birr (US$ 80.08) more, and an aggregate value of around 3,000 birr (US$ 160.17) more than non-members. These findings support the thesis that the devolution of forest tenure rights towards local communities in Ethiopia has positive effects on sustainable development, both in terms of livelihoods and forest quality. Hence, the findings imply that devolution of forest tenure rights to local communities in developing countries has positive effects on sustainable management of forests in general.

The study contributes to the literature on the role of devolution in several ways. First, it investigates the impact of the devolution of forest tenure rights to local communities on sustainable management of forest commons empirically at a disaggregated level using household level dataset. Second, it contributes to filling a gap in the literature, namely the dearth of empirical evidence concerning the link between forest decentralization and poverty alleviation. In particular, the study fills some of the gaps in the data with respect to the implications for local human welfare. The study also highlights the determinants of the assessments of forest condition from both FUG member and non-member households.

In terms of implications for policy, the findings suggest that in order to increase citizen participation in forest commons and sustainable governance of forests, responsible bodies could, among other things, consider promoting trust in people and instituting democratic rules in FUG bylaws.

Regarding caveats, the study uses a cross-sectional dataset. In particular, because we do not carry out any forest measurements, the study uses individual household assessments or perceptions of forest condition as indicators of forest quality. However, using longitudinal and panel datasets that include forest measurement in particular would be important to capture the broader dynamics. Moreover, our study focuses on economic or livelihood-related dimensions. However, other measures of forest condition or quality, such as biophysical and ecological aspects, should also be considered in a comprehensive analysis.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interest or personal relations that may have influenced the work reported in this paper.

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Figures

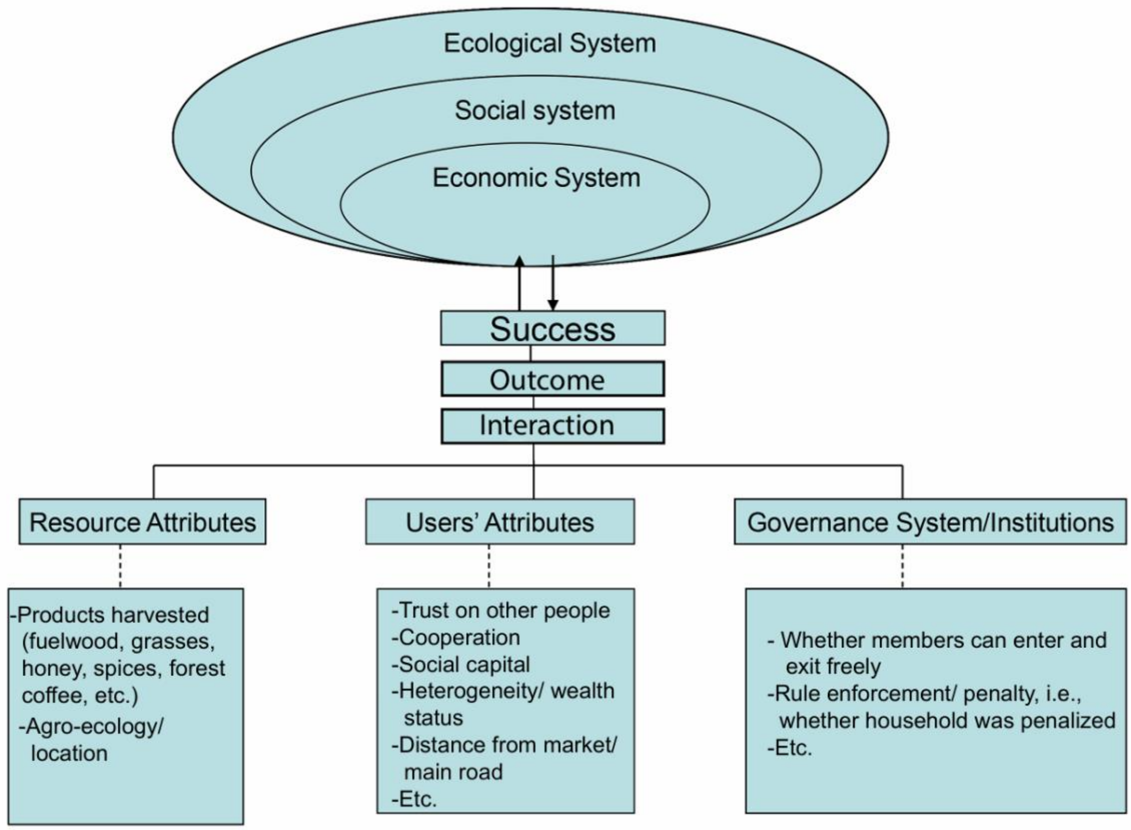

Figure 1: Framework for analyzing the commons

Source: Adapted from Ostrom (2009)

Tables

Table 1. Summary statistics of variables considered: Comparison of FUG members and non-FUG-members

Variable name	Overall (n=600)	FUGs (n=338)	non-FUGs (n=258)	P-value
Quantity of fuelwood harvest (kg)	1273.66	1529.04	916.05	0.002
Value of grass harvest (for thatch, fodder and handicraft) (birr)	70.44	75.75	57.22	0.47
Value of other NTFP (non-timber forest products) harvest (i.e., coffee, spices, and honey) (birr)	1709.85	2187.38	1102.62	0.061
Value of all forest products harvest (aggregate) (birr)	3201.70	4106.86	1994.197	0.001
Land cover (biomass) of the forest	3.29	3.44	3.09	0.54
Diversity of tree species of the forest	3.358	3.37	3.35	0.96
Use of the forest for protection of wildlife	3.41	3.41	3.41	1.00
Whether the household is a FUG member	0.57			
Gender of the household head (1=male)	0.89	0.89	0.90	0.54
Age of the household head	44.78	44.21	45.60	0.32
Marital status (1= married, 0=otherwise)	0.88	0.86	0.90	0.14
Main activity (1= married, 0=otherwise)	0.91	0.92	0.90	0.37
Whether the household head can read and write (1=can read and write, 0=otherwise)	0.63	0.46	.84	0.55
Distance from all-weather road	101.96	82.07	128.43	0.00
Distance from the nearest town / market	183.29	175.98	194.22	0.14
Whether the household head is a member of farmers' cooperatives	0.24	.29	.17	0.00
Trust in people	.43	.46	.39	0.06
Number of extension worker visits in the past 5 years	28.95	29.65	28.09	0.68
Access to credit	0.63	.66	0.38	0.06
Districts				
Andracha	0.13	.23	0	0.00
Dello Mena	0.13	.09	.19	0.00
Fageta Lekoma	0.10	.17	.00	0.00
Gimbo (reference)	0.19	.11	.31	0.00
Goba	0.14	.17	.08	0.00
Kola Tembien	0.10	.14	.05	0.00

Konta	0.10	.04	.18	0.00
Omo Nada	0.10	.03	.19	0.00
Years as a beneficiary	13.20	11.95	15.36	0.00
Whether members can enter and exit freely (1=free)	0.67	.75	.44	0.00
Whether the household has been penalized (1=penalized)	0.03	.04	.01	0.05
Tropical livestock units (TLU)	5.44	5.70	5.00	0.18
Off-farm participation	.26	.31	.19	0.00

Table 2 Logistic model regression results of the determinants of participation decision (dependent variable membership in forest user group / FUG)[a]

Explanatory variables	Estimation results		Average marginal effects	
	Coef.	z-statistics	mfx	z-statistics
Gender	-.204	-0.17	-.046	-0.17
Age	.008	0.83	.002	0.83
Marital status	.949	1.04	.232	1.05
Main activity	.887	1.15	.216	1.15
Able to read and write	-.019	-0.62	-.004	-0.61
Distance to road	-.005***	-2.71	-.001***	-2.61
Distance to market	.003*	1.87	.001*	1.86
Member of farmers' cooperatives	-.519	-1.54	-.120	-1.54
Trust in people	.634**	2.07	.143**	2.12
Number of years as a FUG member	-.067***	-3.96	-.015***	-3.87
Number of extension visits	-.002	-0.70	-.001	-0.70
Access to credit	.032	0.11	.007	0.11
District dummies:				
Delomenna	-.725	-1.50	-.175	-1.47
Fageta Lekome[b]	3.625***	3.20	.458***	9.98
Gimbo (reference)				
Gobba[b]	1.619***	2.77	.295***	3.81
Kola Tembien	.731	1.34	.152	1.53
Konta[b]	-.975*	-1.76	-.237*	-1.76
Omonada[b]	-1.213***	-2.33	-.294***	-2.42
Free entry and exit[b]	1.045***	3.50	.245***	3.52
Whether household was penalized	.746	0.84	.151	0.99
Livestock holding in tropical livestock units (TLU)	.010	0.38	.002	0.38
Participation in off-farm employment	.156	0.47	.036	0.47
Constant	-1.246	-0.85		
Number of observations	520			
LR chi2(22)	218.81			
Prob > chi2	0.0000			
Pseudo R2	0.3817			

a. ***, ** and * stand for significance at the 1%, 5% and 10% level, respectively.
b. Marginal effects, i.e., dx/dy of a discrete change from 0 to 1.

Table 3 Average effect of FUG membership on quantity of fuelwood harvested (kg)

Type of matching	Treatment	Control	ATT_F	AI Robust Std. Err.	z-value[a]
Caliper	310	186	454.19	221.25	2.05**
Nearest-neighbor	310	186	818.03	273.84	2.29***
IPW[b]	310	186	623.89	205.89	3.03***

c. *** and ** stand for significance at the 1% and 5% level, respectively.
d. IPW stands for inverse probability weighting.

Table 4 Average effect of FUG membership on the value of the grass (thatch, fodder, and handicraft) harvest in Ethiopia birr (ETB)[c]

Type of matching	Treatment	Control	ATT_G	AI Robust Std. Err.	z-value
Caliper	310	186	28.00	20.76	1.35
Nearest-neighbor	310	186	41.02	21.28	1.93**
IPW	310	186	19.07	23.00	0.85

c ETB is the Ethiopian currency. 1 USD = 18.73 ETB during the survey period

Table 5 Average effect of FUG membership on the value of the other NTFP (non-timber forest products) (i.e., coffee, spices, and honey) harvest in ETB

Type of matching	Treatment	Control	ATT_N	AI Robust Std. Err.	z-value
Caliper	310	186	1498.17	518.28	2.89***
Nearest-neighbor	310	186	1407.72	579.52	2.43***
IPW	310	186	1500.44	501.27	2.99***

Table 6 Average effect of FUG membership on the aggregate value of the harvest of all forest products in ETB

Type of matching	Treatment	Control	ATT_N	AI Robust Std. Err.	z-value
Caliper	310	186	2829.25	637.35	4.44***
Nearest-neighbor	310	186	2875.42	704.42	4.08***
IPW	310	186	2628.34	575.71	4.57***

Table 7 Ordered logit model estimates (standard error in parenthesis) of determinants of FUG member and non-member assessments of forest quality
(dependent variables - ratings: 1= decreased significantly, …, 5= increased significantly)

Dependent Variables	Y1 (Land cover / biomass)	Y2 (Species diversity)	Y3 (Wildlife protection)
Membership of FUGs	1.042***(.247)	1.330***(.254)	1.099***(.249)
Gender	-.094(.731)	-.100(.697)	-.526(.721)
Age	.009(.007)	.005(.007)	.003(.007)
Marital status	-.362(.609)	-.294(.591)	.286(.583)
Main activity	-.003(.522)	.174(.507)	-.507(.539)
Ability to read and write	-.017(.020)	-.007(.020)	-.000(.018)
Distance to road	-.003***(.001)	-.004***(.001)	-.002(.001)
Distance to market	.002*(.001)	.004***(.001)	.001(.001)
Member of farmers' associations	-.544***(.214)	-.423**(.211)	-.118(.210)
Trust in people	.101(.199)	-.288(.198)	.064(.193)
Number of years as a FUG member	-.027***(.010)	-.007(.010)	-.011(.010)
Number of extension visits	-.004*(.002)	-.001(.002)	-.003(.002)
Access to credit	-.332*(.196)	-.156(.193)	-.174(.192)

District dummies:			
Andracha	.782**(.341)	.902***(.336)	.754**(.337)
Delomenna	.980***(.365)	.983***(.370)	1.534***(.377)
Fageta Lekome	.709*(.396)	-.139(.376)	1.033***(.393)
Gimbo (reference)			
Gobba	.325(.390)	.738*(.393)	1.127***(.389)
Konta	1.936***(.430)	2.272***(.439)	2.831***(.447)
Kola Tembien	1.473***(.435)	1.662***(.433)	1.485***(.431)
Omonada	1.167***(.401)	.947**(.402)	1.214***(.385)
Free entry and exit	.007(.205)	.002(.203)	.695***(.206)
Penalized	1.657***(.608)	.429(.512)	.443(.516)
Total TLU	-.009(.013)	-.007(.013)	-.012(.013)
Participation in off-farm employment	.126(.213)	.181(.209)	.061(.209)
Cut1	-6.617***(1.140)	-5.333***(.1.110)	-5.205***(1.128)
Cut2	-6.209***(1.065)	-2.491***(.877)	-2.092***(.895)
Cut3	-3.821***(.917)	-1.006(.867)	
Cut4	-2.173(.905)		
Cut5		2.201***(.870)	2.193***(.895)
Number of observations	496	496	496
LR chi2(24)	159.77	155.02	139.31
Prob > chi2	0.000	0.000	0.000
Pseudo R2	0.1149	0.110	0.100

Table 8 Average marginal effects (standard error in parenthesis) of each covariate on P[Y], dy/dx

Variable	P[Y1 = 1]	P[Y1 = 2]	P[Y1 = 3]	P[Y1 = 4]	P[Y1 = 5]	P[Y2 = 1]	P[Y2 = 2]	P[Y2 = 3]	P[Y2 = 4]	P[Y2 = 5]	P[Y3 = 1]	P[Y3 = 2]	P[Y3 = 3]	P[Y3 = 4]	P[Y3 = 5]
FUG Member *	-.032*** (.011)	-.102*** (.028)	-.065*** (.017)	.023 (.020)	.179*** (.040)	-.050*** (.014)	-.123*** (.028)	-.106*** (.022)	.084*** (.028)	.198*** (.036)	-.050*** (.015)	-.096*** (.025)	-.074*** (.018)	.039* (.022)	.183*** (.039)
Gender*	.002 (.018)	.008 (.062)	.006 (.046)	.001 (.013)	-.018 (.141)	.003 (.020)	.008 (.055)	.009 (.060)	-.003 (.015)	-.017 (.120)	.016 (.018)	.036 (.042)	.035 (.045)	.017 (.055)	-.106 (.160)
Age	-.000 (.000)	-.001 (.001)	-.001 (.000)	-.000 (.000)	.002 (.001)	-.000 (.000)	-.000 (.000)	-.000 (.001)	.000 (.000)	.001 (.001)	-.000 (.000)	-.000 (.000)	-.000 (.000)	.000 (.000)	.000 (.001)
Marital status*	.008 (.012)	.029 (.044)	.022 (.036)	.011 (.037)	-.072 (.130)	.008 (.014)	.022 (.041)	.025 (.049)	-.004 (.008)	-.052 (.111)	-.013 (.029)	-.025 (.054)	-.020 (.041)	.010 (.035)	.048 (.091)
Main activity*	.000 (.014)	.0003 (.047)	.000 (.034)	.000 .001)	-.001 (.097)	-.006 (.018)	-.015 (.047)	-0.015 (.044)	.009 (.034)	.027 (.075)	.016 (.014)	.035 (.032)	.034 (.034)	.015 (.040)	-.102 (.119)
Can read and write	.000 (.000)	.001 (.002)	.001 (.001)	.000 (.000)	-.003 (.004)	.000 (.000)	.001 (.002)	.001 (.002)	-.000 (.001)	-.001 (.003)	.000 (.001)	.000 (.001)	.000 (.001)	-.000 (.000)	-.000 (.003)
Distance to road	.000 (.000)	.0003*** (.0001)	.0002*** (.0001)	.000 (.000)	- .001*** (.000)	.0001*** (.000)	.0003*** (.0001)	.0003*** (.0001)	- .0001** (.000)	.001*** (.000)	.000 (.000)	.000 (.000)	.000 (.000)	-.000 (.000)	-.000 (.000)
Distance to nearest market	-.000 (.000)	-.0002* (.0001)	-.0001* (.0001)	-.000 (.000)	.0004* (.0002)	- .0001*** (.0000)	- .0003*** (.0001)	- .0004*** (.0001)	.0001** (.0001)	.001*** (.000)	-.000 (.000)	-.000 (.000)	-.000 (.000)	.000 (.000)	.000 (.000)
Farmers' assoc. member	.014** (.006)	.049*** (.020)	.035** (.015)	.000 (.009)	- .101*** (.040)	.013* (.007)	.035** (.018)	.037** (.019)	-.017 (.011)	-.069** (.035)	.005 (.008)	.009 (.017)	.008 (.015)	-.001 (.003)	-.021 (.038)
Trust in people*	-.003 (.005)	-.009 (.018)	-.006 (.013)	-.000 (.002)	.019 (.037)	.009 (.007)	.024 (.017)	.025 (.017)	-.012 (.010)	-.046 (.032)	-.002 (.007)	-.005 (.015)	-.004 (.014)	.001 (.002)	.012 (.035)
No. of extension visits	.0001* (.000)	.0003* (.0002)	.0002* (.0001)	.000 (.000)	-.001* (.000)	.000 (.000)	.000 (.000)	.000 (.000)	-.000 (.000)	-.000 (.000)	.000 (.000)	.000 (.000)	.000 (.000)	-.000 (.000)	-.000 (.000)
Access to credit	.009 (.005)	.030* (.018)	.021* (.012)	.000 (.006)	-.061* (.036)	.005 (.006)	.013 (.016)	.014 (.017)	-.006 (.008)	-.026 (.032)	.007 (.008)	.014 (.016)	.012 (.014)	-.002 (.004)	-.031 (.035)
District dummies:															
Andracha*	-.016*** (.006)	-.059*** (.022)	-.047*** (.020)	-.038 (.034)	.162*** (.077)	-.021*** (.007)	-.061*** (.020)	-.073*** (.026)	-.016 (.028)	.173*** ((.073)	-.024*** (.009)	-.051*** (.020)	-.050** (.022)	-.026 (.028)	.153*** (.075)
Delomena *	-.019*** (.006)	-.070*** (.021)	-.056*** (.020)	-.063 (.045)	.210*** (.086)	-.022*** (.007)	-.064*** (.020)	-.078*** (.027)	-.027 (.036)	.193** (.083)	-.038*** (.009)	-.086*** (.017)	-.089*** (.020)	- .122** (.057)	.337*** (.089)
Fageta Lekoma*	-.015** (.007)	-.053** (.025)	-.042* (,022)	-.035 (.039)	.148* (.090)	.004 (.013)	.012 (.034)	.012 (.033)	-.007 (.022)	-.022 (.058)	-.029*** (.009)	-.064*** (.019)	-.065*** (.023)	-.059 (.048)	.219*** (.092)
Gimbo (reference)															
Gobba*	-.008	-.027	-.020	-.007	.064	-.018**	-.051**	-.061**	-.008	.140*	-.031***	-.069***	-.071***	-.068	.240***

	(.008)	(.030)	(.024)	(.018)	(.080)	(.008)	(.023)	(.030)	(.027)	(.083)	(.009)	(.019)	(.022)	(.049)	(.092)
Kola Tembien*	-.024*** (.006)	-.089*** (.019)	-.076*** (.019)	-.141 (.071)	.332*** (.104)	-.030*** (.007)	-.088*** (.017)	-.115*** (.024)	-.123* (.070)	.358*** (.104)	-.035*** (.008)	-.081*** (.017)	-.085*** (.021)	-.127* (.069)	.331*** (.103)
Konta*	-.028*** (.007)	-.106*** (.017)	-.091*** (.018)	-.209*** (.071)	.438*** (.095)	-.036*** (.008)	-.107*** (.016)	-.140*** (.022)	-.210*** (.071)	.495*** (.094)	-.051*** (.010)	-.115*** (.016)	-.125*** (.019)	-.315*** (.058)	.609*** (.072)
Omonada*	-.020*** (.006)	-.076*** (.019)	-.064*** (.019)	-.095 (.061)	.258*** (.098)	-.021*** (.007)	-.061*** (.020)	-.075*** (.018)	-.031 (.043)	.189** (.093)	-.031*** (.008)	-.070*** (.017)	-.073*** (.021)	-.089 (.057)	.266*** (.093)
noyearsb	.007** (.0003)	.002*** (.001)	.002*** (.001)	.000 (.000)	-.005*** (.002)	.000 (.000)	.001 (.001)	.001 (.001)	-.000 (.000)	-.001 (.002)	.000 (.000)	.001 (.001)	.001 (.001)	-.000 (.000)	-.002 (.002)
entryexi*	-.0002 (.005)	-.001 (.019)	-.000 (.013)	-.000 (.000)	.001 (.038)	-.000 (.006)	-.000 (.017)	-.000 (.018)	.000 (.008)	.000 (.033)	-.030*** (.011)	-.059*** (.019)	-.048*** (.015)	.020 (.015)	.119*** (.033)
penalizd*	-.023*** (.006)	-.089*** (.019)	-.079*** (.020)	-.189* (.108)	.382*** (.143)	-.011 (.011)	-.031 (.032)	-.036 (.041)	.001 (.020)	.079 (.103)	-.014 (.014)	-.031 (.032)	-.030 (.033)	-.011 (.033)	.088 (.112)
totaltlu	.0002 (.0003)	.001 (.001)	.001 (.001)	.000 (.000)	-.002 (.002)	.000 (.000)	.001 (.001)	.001 (.001)	-.000 (.000)	-.001 (.002)	.000 (.000)	.001 (.001)	.001 (.001)	-.000 (.000)	-.002 (.002)
offfarmp*	-.003 (.005)	-.011 (.018)	-.008 (.014)	-.001 (.003)	.024 (.041)	-.005 (.006)	-.015 (.017)	-.016 (.018)	.006 (.006)	.030 (.036)	-.002 ((.008)	-.005 (.016)	-.004 (.015)	.000 (.002)	.011 (.038)

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Appendices

Table A1. Definition, measurement and expected sign of the variables considered in the analysis

Symbol	Variable name /Description	Measurement	Expected sign
Outcome variables			
Y1	Quantity of fuelwood harvest	Kilogram	
Y2	Value of grass harvest (for thatch, fodder and handicraft)	Birr	
Y3	Value of other NTFP (non-timber forest products) harvest (i.e., coffee, spices, and honey)	Birr	
Y4	Values of all forest products harvest (aggregate)	Birr	
Other (additional) indicators of forest quality			
Y5	Land cover (biomass) of the forest	On a five-point Likert-scale ranking of forest condition: (5) increases significantly; (4) increases; (3) No change; (2) decreases; (1) decreases significantly	
Y6	Diversity of tree species of the forest	>>	
Y7	Use of the forest for protection of wildlife	>>	
Treatment variable			
M	Whether household is a FUG member	=1 if yes, 0 otherwise	
Confounding variables (covariates)			
X1	Gender of the household head	=1 if male, 0 otherwise	(+)/(-)
X2	Age of the household head	Years	(+)/(-)
X3	Marital status	=1 if married, 0 otherwise	(+)/(-)
X4	Main activity	=1 if farmer, 0 otherwise	(+)/(-)
X5	Whether the household head can read and write.	=1 if can read & write, 0 otherwise	(+)
X6	Distance from all-weather road (round trip)	Minutes	(+)
X7	Distance from the nearest market (round trip)	Minutes	(+)

X8	Whether the household head is a member of farmers' cooperatives	=1 if member, 0 otherwise	(+)
X9	Trust in other people	=1 if yes, 0 otherwise	(+)
X10	Number of extension worker visits in the past 5 years	Number	(+)/(-)
X11	Credit access	=1 if yes, 0 otherwise	(+)/(-)
X12	District dummies:		
	Kola Tembien	=1 if yes, 0 otherwise	(+)/(-)
	Fageta Lekoma	=1 if yes, 0 otherwise	(+)/(-)
	Omo Nada	=1 if yes, 0 otherwise	(+)/(-)
	Goba	=1 if yes, 0 otherwise	(+)/(-)
	Dello Mena	=1 if yes, 0 otherwise	(+)/(-)
	Gimbo	=1 if yes, 0 otherwise	(+)/(-)
	Anderacha	=1 if yes, 0 otherwise	(+)/(-)
	Konta	=1 if yes, 0 otherwise	(+)/(-)
X13	Years as a beneficiary	Number of years	(-)/(+)
X14	Whether members can enter and exit freely	=1 if free, 0 otherwise	(+)
X15	Whether the household has been penalized	=1 if penalized, 0 otherwise	(-)
X16	Livestock owned	Tropical Livestock Units (TLU)	(-)
X17	Off-farm participation	=1 if yes, 0 otherwise	(-)

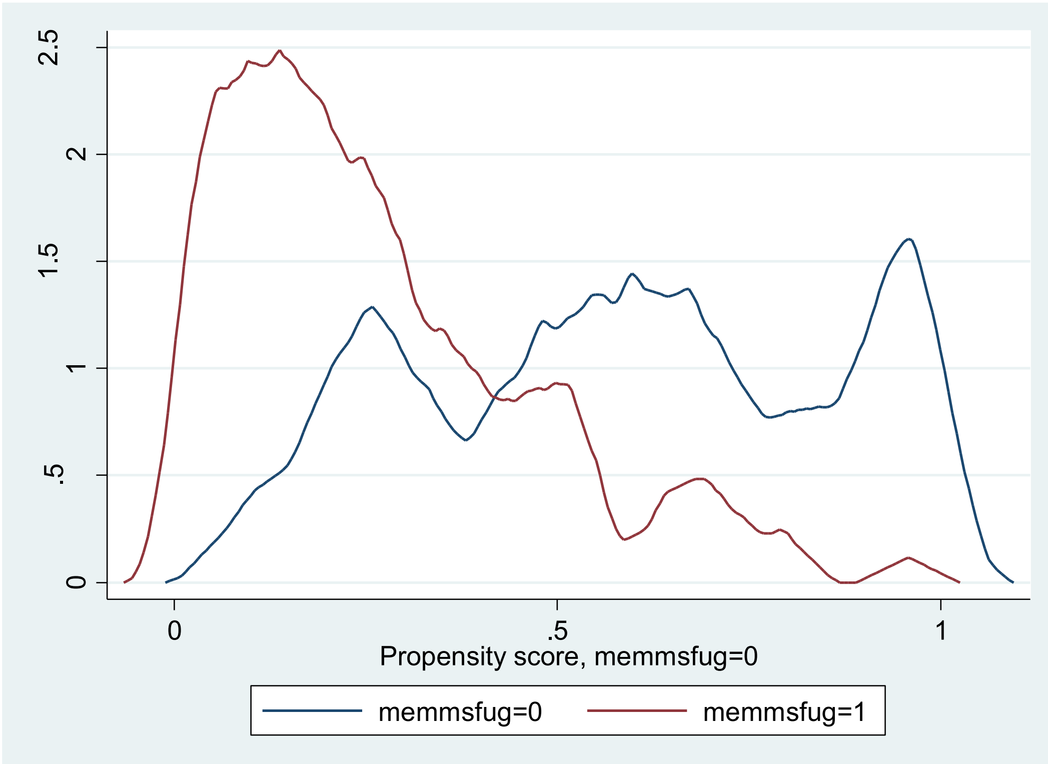

Figure A1. Density of the probability of obtaining each treatment level in relation to the outcome variable quantity of fuelwood harvest. [a]

[a] **memmsfug** stands for membership in forest user groups (FUGs): 0=no, and 1=yes.

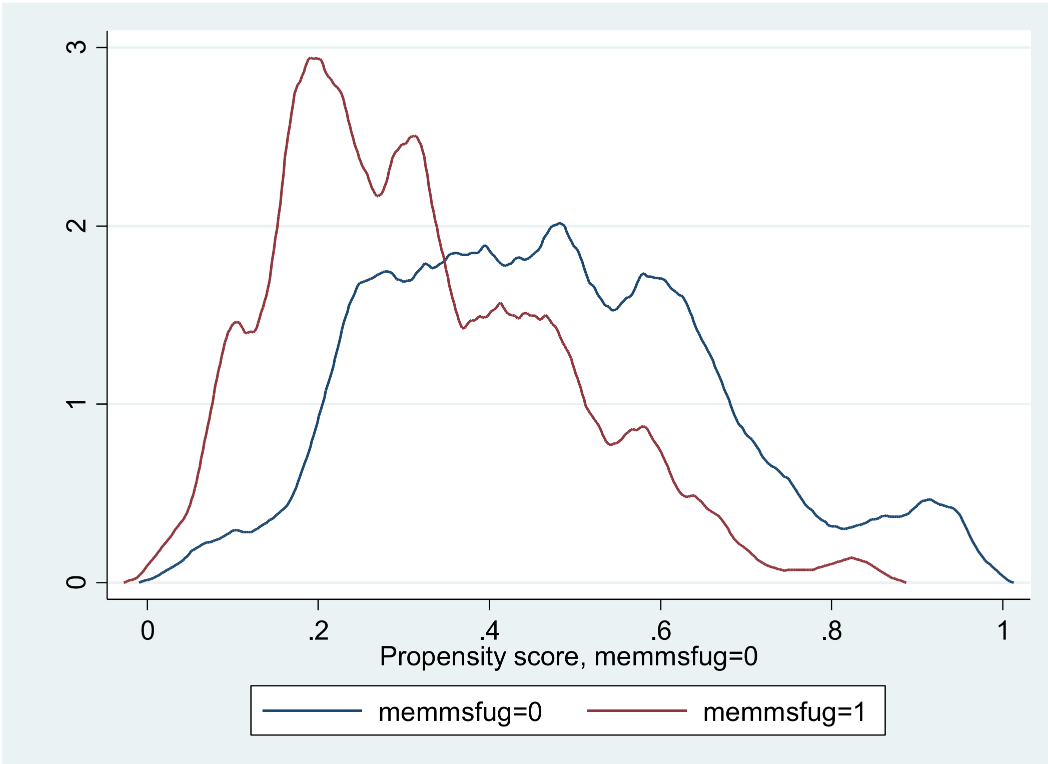

Figure A2. Density of the probability of obtaining each treatment level in relation to the outcome variables: i) value of the grass (thatch, fodder and handicraft) harvest; ii) value of the other NTFP (non-timber forest products) (i.e., coffee, spices, and honey) harvest; and iii) (aggregate) value of harvest from all forest products.