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Evidence of Behavioral Effects from Highland Ethiopia

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Abstract

This paper attempts to analyze the correlates of (1) aggregated and disaggregated indices of common property forest management (CPFM) as perceived by households, and (2) the decision to grow trees and the number of trees grown with the objective of looking at the effect of CPFM. We used data collected in 2007 from a sample of rural households in the Amhara region of Ethiopia. While the CPFM indices we used varied across households, the overall CPFM index and its two sub-indices (management tools and institutional characteristics) showed a generally low level of management. We observed significant differences in the nature of management of community forests across sites, mainly driven by population size, population density, and size of forests. The results also showed that the overall management of community forests, as reflected by the overall CPFM index and its two sub-indices, had a positive association with the decision to grow trees on-farm as well as the number of trees grown. These results suggest that households that perceive a more strict management are more likely to grow trees on their farm and that those which do grow trees grow more trees. A strong correlation between the different CPFM indices suggests that households perceived the components of CPFM as being similar and hence these components were, in this case, indistinguishable.

Key Words: Common forest management, private trees, Ethiopia

JEL Classification: Q23, Q12

Contents

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Introduction

In most low-income developing countries, households depend on trees to provide a variety of products that are essential to daily life, including fuelwood, fodder for animals, and building materials. Furthermore, forests may provide important local "off-site" benefits, including erosion and flood control.

Often forests are "common," which creates interdependencies between community members that may result in open access, which provides few incentives for stewardship, planting, and management (Gordon 1954). Without clear property rights, as long as resources have value, they will be used in less than ideal ways and almost certainly will be degraded, often to the point where they end up close to worthless. Sometimes this phenomenon is called the "Tragedy of the Commons" (Hardin 1968) and reflects the idea that potentially very valuable resources can be degraded when it is not clear who gets the products generated from natural resource investments and/or who has the right to control resources.[1]

Establishing clear property rights through appropriate institutional arrangements is therefore perhaps *the* critical prerequisite to enhanced tree planting, stewardship, management, and tree cover in many low-income countries. Clarifying property rights may not solve all problems, but the economic literature is doubtful that tree cover can be sustainably increased without clear property rights (Gordon 1954; Hartwick and Olewiler 1998; Field 2001)

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[1] Because it is now recognized that it is not the *common* nature of resources but the openness of access that causes the tragedy, in modern terminology, it would be referred to as the tragedy of open access.

In Ethiopia, which is the focus of this paper, property rights in rural areas are often very weak and this is particularly true for common grazing and forest areas (Mekonnen and Bluffstone 2008). People, therefore, typically use the land as they want with very limited management; as rural populations and demands on common lands have increased, it is perhaps not surprising that forest cover has declined.

What institutional arrangements can be used to establish property rights? Private property, of course, is a possibility, and it certainly creates the right incentives for forest management if there are few conflicts between uses of forests. For example, if trees only produce fuelwood, private property may be the correct institutional arrangement because there are few ways co-owners of fuelwood plantations can infringe on each others' property rights. Privatization of common lands would therefore likely be the correct solution.

But, in Ethiopia as in most low-income countries, common forests typically produce multiple products, creating technical barriers to privatization. Furthermore, allocation of forest resources is highly political and poor villagers may be deprived of historical rights. Poor villagers, who often rely much *more* heavily on common lands than rich villagers (Jodha 1986), may as a result find themselves worse off than when land was open access.

Alternatives to open access and private property are limited. Creating government ownership is a tempting possibility, but as seems to be the case in Ethiopia and many other low-income countries (where all land is state-owned), state property often functions as *de facto* open access. A more promising institutional arrangement is common property in which users of forests jointly own resources. Devolution of forest management to local-level institutions with the goal of creating incentives for stewardship, planting, and management of common lands has therefore become an increasingly important tool when forests mainly generate direct use values (Agrawal 2007).

If common property forest management (CPFM) really offers incentives for better management than open access, we should observe behavioral differences when better management exists. In this analysis, we tried to isolate and understand the effect of generally-considered better CPFM on households' incentives to invest in on-farm tree planting. As a small but growing literature is establishing, private tree planting is a potentially important behavioral response to better social coordination and higher levels of social capital, like CPFM (Nepal et al. 2007; Bluffstone et al. 2008; Mekonnen [forthcoming]). Furthermore, in East Africa as common forests have deteriorated, very small private plantations are increasingly producing critical forest products for rural households (Bluffstone et al. 2007)

With this paper, we seek to contribute to the growing—but still inadequate—literature on the determinants of CPFM and household responses to different aspects of CPFM. To our knowledge, this is also the first study in Africa that looks into the links between CPFM and private tree planting. Using an analytical household model, we found that better CPFM should create incentives for tree planting. We tested this hypothesis using household data from highland Ethiopia and found support for this analytical finding. We therefore concluded that better CPFM causes households to change their behavior, and one effect is more on-farm tree planting.

The next section discusses the literature related to CPFM. Section 3 presents a household analytical model based on that used by Bluffstone et al. (2008). Section 4 discusses the forestry situation in Ethiopia and our data. Section 5 discusses the econometric approach used and results, and Section 6 concludes.

1. Literature on Common Property Forest Management and Household Behavior

In recent decades, there have been important advances in our understanding of the management of commonly held natural resources. In the process, an enormous literature has emerged that discusses the incentives for community members to cooperate and emphasizes the need for individual interests to be deferred to enhance the long-term community interest. This literature implies that with effective CPFM households would be forced to restrict their collections compared with desired levels (e.g., Olson 1965; Dayton-Johnson 2000; Wade 1988; Ostrom 1990; Bromley 1990; Baland and Platteau 1996; Sethi and Somanathan 1996; Baland and Platteau 1999; Bluffstone et al. 2008).

A related literature discusses desirable aspects of CPFM and attempts to disaggregate its components. This work suggests that policies that empower communities and that have clear access and extraction rules, fair and graduated sanctions, public participation, and successful monitoring are most effective (Ostrom 1990; Agrawal 2000, 2001). We divided these believed best practices into institutional characteristics and management tools. Institutional characteristics are the basic values and arrangement of institutions. For example, clarity of access to forest resources, fairness, democracy, and public participation are institutional characteristics. Management tools are instruments used to encourage members to mitigate their use of forests or improve forest quality. Fixed allotments of fuelwood and fodder, monitoring by officials and villagers, formal and informal sanctions, and work to improve forest quality are all management tools.

Despite what is an emerging conventional wisdom that CPFM is better than other alternatives, evidence on the efficacy of CPFM components is still limited and the subject of current empirical research; indeed, empirical work focusing on CPFM elements that spur behavioral change has only relatively recently emerged (Hegan et al. 2003; Adhikari 2002; Amacher et al. 1996, 1999; Cooke 2000, 2004; Edmonds 2002; Heltberg 2001; Heltberg et al. 2000; Linde-Rahr 2003).

The work of Nepal et al. (2007), Bluffstone et al. (2008) and Mekonnen (forthcoming) is directly related to our paper because of their focus on incentives for on-farm tree planting. Nepal et al. (2007) looked at a variety of social networks and found that forest-related institutions particularly spur on-farm tree planting. Other less forest-related groups have limited effects. Bluffstone et al. (2008) used a methodology similar to that used in this paper to examine whether CPFM spurs on-farm tree planting in Bolivia. They found that better CPFM at its highest level of aggregation—and especially the institutional characteristics component—is positively correlated with more and higher quality on-farm trees. In terms of less aggregated indices, relatively few variables are significant, although two specific property rights aspects of CPFM may reduce on-farm planting. Mekonnen (forthcoming) looks at tree planting in Ethiopia and finds that a variety of labor, asset, and credit market imperfections affect on-farm tree planting.

2. A Household Analytical Model and Comparative Static Results

The theoretical and applied literatures suggest that effective CPFM should result in higher quality forests by restricting household deforesting behavior. Because households' most important variable factor is labor, we modeled[2] these restrictions as inequality constraints on forest-related labor supply. Following Heltberg (2001) and Platteau and Abraham (2002), it is supposed that forest policies are endogenous, but taken as given when villagers make their day-to-day decisions. Village households maximize utility, which is a function of cooked grains (g_c), cooked meat (m_c), and other goods (X) that must be purchased (equation 1). First derivatives are positive and cross-partials zero.

$$U = U(g_c, m_c, X) \tag{1}$$

[2] This model is based on that of Bluffstone et al. (2008).

Cooked grains (g_c) are produced by combining fuel, raw grains, and household labor. Fuelwood may be collected by households (f) or purchased (F). Households may also sell fuelwood (f_s). Grains can be produced (g) or purchased in the market (G). Households may also sell grains (g_s). These inputs are combined with home effort (E_H) to produce food (equation 2).

$$g_c = g_c\{(f + F - f_s), (g + G - g_s), E_H\} \quad (2)$$

Equation 3 is the production function for meat (m_c), which is a function similar to that for cooked grains. The only difference is that meat is not purchased. Meat is a positive function of animals (A), such as cattle, goats, and sheep that are held by households.

$$m_c = m_c\{(f + F - f_s), A, E_H\} \quad (3)$$

Grains are produced using household labor (E_g). Labor is complemented by land (L) that is fixed and animals (A), which provide dung fertilizer and traction power (equation 4). Animals provide no inter-temporal benefits. First derivatives are positive and second derivatives negative in this and the following three production functions.

$$g = g\{E_g, A, L\} \quad (4)$$

Fuelwood is produced using time (E_f) applied to common forests (Q) and trees on-farm (T). Higher quality commons offer the possibility to produce more fuelwood with a given input of E_f. On-farm trees are pure substitutes for common forests (equation 5)

$$f = f\{E_f, Q, T\} \quad (5)$$

Equation 6 presents the animal production function. Animals are produced using grazing (E_{gr}) and fodder collection (E_{fo}) labor combined with Q and T.

$$A = A\{E_{fo}, E_{gr}, Q, T\} \quad (6)$$

Production occurs subject to the time constraint in equation 7. All on-farm activities are included, as well as off-farm wage labor (E_w). Leisure was not considered because the labor-leisure tradeoff was not germane to our research questions.

$$E_T = E_g + E_f + E_{fo} + E_{gr} + E_w + E_H \quad (7)$$

There is no saving or borrowing. Cash is earned from wages at rate *w*, sales of grains at price P_g, and sales of wood at price P_F. Cash is spent on grains, priced at P_g, fuelwood priced at P_F, and purchased non-food goods (X), which come at a per unit cost of P_X (equation 8).

$$wE_w + P_g g_s + P_F f_s = P_g G + P_F F + P_x X \tag{8}$$

Three inequality constraints take into account that households' forest-dependent activities could be restricted by CPFM. Examples include allowable cutting of fuelwood, maximum days grazing, that households take what they need but not more, or that allocations be fair (equation 9)

$$\begin{aligned} &Ef^* - Ef \geq 0 \\ &Efo^* - Efo \geq 0 \\ &Egr^* - Egr \geq 0 \end{aligned} \tag{9}$$

Equation 6 is substituted into (3) and (4). Equation 5 can be substituted into (2) and (3), which is then substituted into (1). Assuming linearity in the utility function, the Lagrangian representing the household's maximization problem is given in (10). λ_1 and λ_2 are the Lagrange multipliers on the time and budget constraints. λ_3, λ_4, and λ_5 are policy multipliers.

Equation 10

$$\begin{aligned} L = {} & ag_c[\{ f(E_f, Q, T) + F\} - f_s, \{g(E_g, \langle A(E_{fo}, E_{gr}, Q, T)\rangle, L) - g_s\} + G, E_H] + \\ & bm_c[\{ f(E_f, Q, T) + F\} - f_s, \langle A(E_{fo}, E_{gr}, Q, T)\rangle, E_H] + cX + \lambda_1(E_T - E_g - E_f - E_{gr} - E_{fo} - E_w - E_H) \\ & + \lambda_2(wE_w + P_g g_s + P_F f_s - P_g G - P_F F - P_x X) + \lambda_3(E_{f^*} - E_f) + \lambda_4(E_{fo^*} - E_{fo}) \\ & + \lambda_5(E_{gr^*} - E_{gr}) \end{aligned}$$

The endogenous variables are Eg, E_f, E_{fo}, E_{gr}, E_H, E_w, F, f_s, g_s, G, and X. Maximizing the Lagrangian with respect to these variables yields twelve first order conditions. Because our focus was on tree planting in response to CPFM, we only present first order conditions (FOCs) for F and labor allocation variables dealing with common forests. Complementary slackness requires that either the differences in the constraints equal zero or if constraints do not bind, the Lagrange multipliers are zero. Looking at effects if λ_3, λ_4, λ_5 are positive or zero, therefore, allows us to predict the adoption effects when CPFM imposes binding labor constraints. Non-negative values for λ_3, λ_4 and λ_5, therefore, represent the use of binding CPFM.

Equation 11

$$a.\ \frac{\partial L}{\partial E_g} = a\frac{\partial g_c}{\partial g}\frac{\partial g}{\partial E_g}(Q,T) - \lambda_1 = 0$$

$$b.\ \frac{\partial L}{\partial E_f} = as\frac{\partial g_c}{\partial f}\frac{\partial f}{\partial E_f}(Q,T) + bs\frac{\partial m_c}{\partial f}\frac{\partial f}{\partial Ef}(Q,T) - \lambda_1 - \lambda_3 = 0$$

$$c.\ \frac{\partial L}{\partial E_{fo}} = a\frac{\partial g_c}{\partial g}\frac{\partial g}{\partial A}\frac{\partial A}{\partial E_{fo}}(Q,T) + b\frac{\partial m_c}{\partial A}\frac{\partial A}{\partial E_{fo}}(Q,T) - \lambda_1 - \lambda_4 = 0$$

$$d.\ \frac{\partial L}{\partial E_{gr}} = a\frac{\partial g_c}{\partial g}\frac{\partial g}{\partial A}\frac{\partial A}{\partial E_{gr}}(Q) + b\frac{\partial m_c}{\partial A}\frac{\partial A}{\partial E_{gr}}(Q) - \lambda_1 - \lambda_5 = 0$$

$$e.\ \frac{\partial L}{\partial E_w} = -\lambda_1 + \lambda_2 w = 0$$

$$f.\ \frac{\partial L}{\partial F} = as\frac{\partial g_c}{\partial F} + bs\frac{\partial m_c}{\partial F} - \lambda_2 P_F = 0$$

We substituted 11e into 11f and the result into 11b. Rearranging, gives equation 12:

$$a\frac{\partial g_c}{\partial F} + b\frac{\partial m_c}{\partial F} + \frac{1}{s}\frac{P_F}{w}\lambda_3 = a\frac{P_F}{w}[\frac{\partial g_c}{\partial f}\frac{\partial f}{\partial E_f}(Q,T) + \frac{\partial m_c}{\partial f}\frac{\partial f}{\partial E_f}(Q,T)] \qquad (12)$$

If λ_3 is positive, binding fuelwood collection constraints exist. To maintain equality the right-hand side must rise or components of the left-side must decline. One possibility is that $\partial f/\partial E_f$ could rise, which could happen if on-farm tree planting (T) increased. We therefore expect that CPFM should increase on-farm tree planting. With constraints on fodder collection and grazing (i.e., if we use 12c or 12d rather than 12b), similar results can be shown.

The intuition behind this result is straightforward. Faced with constraints on access to forests in the interest of the public good, households look for private second-best alternatives to common forests. Planting of on-farm trees is one important possibility. Yet this analytical result is merely a hypothesis that may or may not hold in Ethiopia. The remainder of this paper thus focuses on testing whether better CPFM indeed spurs on-farm tree planting.

3. Ethiopian Forestry Situation and Data Used

With an estimated 4.6 percent forest cover, 0.8 percent additional deforestation per year, and 83.3 percent of the population living in rural areas (World Bank 2005)—therefore at least partially dependent on forests for livelihoods—the forestry situation in Ethiopia is problematic. This compares with a baseline of perhaps 40 percent forest cover in the 16th century (EFAP 1994; Tumcha 2004). World Bank (2005) presented data showing that the world average forest cover is about 30 percent of total land area while at 27.3 percent for sub-Saharan Africa the percentage forested is about six times more than Ethiopia.

Ethiopia has a rapidly growing human population of about 80 million, largely dependent on low-productivity and rain-fed agriculture. There are also over 70 million livestock that compete for land and forest resources. As noted by the Food and Agricultural Organization of the United Nations, this is causing hardship for people. *The current demographic and socio-economic conditions have led to an unprecedented pressure on [the remaining] mountain forest ecosystems*. It found that over 90 percent of the country's energy for household cooking comes from fuelwood.[3] In 2006 and 2007, floods potentially linked to lack of tree cover killed hundreds and resulted in significant property damage.

Policy reform to increase tree cover is a government priority, with a forest proclamation issued in 2007 and the first-ever federal forest policy approved the same year. Both these documents allow a variety of institutional arrangements for investment in forests, including CPFM, private woodlots, and on-farm trees.

We used household and community-level data collected in 2007 from a sample of largely subsistence rural households that mainly rely on mixed crop and livestock farming in East Gojam and South Wollo zones of the Amhara Regional State in Ethiopia. Ten village areas called peasant associations are covered by the survey. Peasant associations were selected to ensure variation in terms of characteristics, such as agro-ecology and tree cover, with households selected randomly. Figure 1 shows the location of the study sites.

Descriptive statistics are presented in tables 1–4. Table 1 shows that 82 percent of households grew trees. On average, a household had about 290 trees, with a large variation across households. We also note from table 1 that about 70 percent of households grew eucalyptus trees and the average number per household is about 237, which makes eucalyptus the most frequently planted tree species.[4]

[3] Food and Agricultural Organization, http://www.fao.org/forestry/site/countryinfo/en/.

[4] Surveys in 2000, 2002, and 2005 of the same households showed that eucalyptus trees were the most important trees in terms of number of households growing and trees grown (see Mekonnen [forthcoming]).

Figure 1 Locations of Study Sites

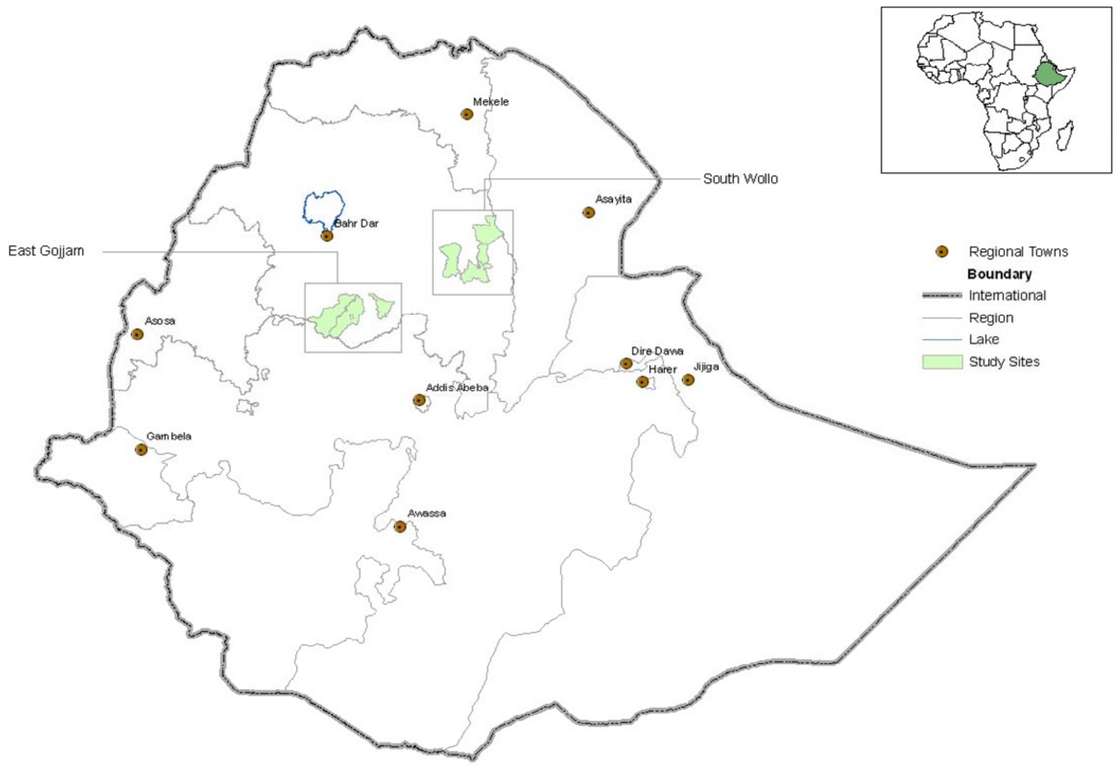

Table 1 Descriptive Statistics on Tree Growing

Variable label	Mean	Std. dev.	Min.	Max.
Grows trees	0.82	0.39	0	1
Grows eucalyptus trees	0.70	0.46	0	1
Number of trees grown	241.38	492.58	0	4011
Number of eucalyptus trees grown	196.95	459.84	0	3950

To analyze the effects of various aspects of CPFM on household behavior, we constructed an index of overall CPFM and its two sub-indices—institutional characteristics and management tools—as well as a variety of components of these two sub-indices. We then evaluated the relationship between these indices and on-farm tree planting. We created the CPFM indices on the basis of criteria suggested by Ostrom (1990) and Agrawal (2001) and included disaggregated measures to evaluate whether it was the package of CPFM components or some of the individual aspects that caused households to respond to CPFM by planting trees on-farm. Bluffstone et al. (2008), for example, used similarly-constructed indices and found that while individual components in the Bolivian Andes typically had limited effect, the overall CPFM index strongly influenced on-farm tree planting. Five of these are components of management tools (labor requirements, social sanction, penalty, monitoring, and clarity of quotas) and three are aspects of institutional characteristics (participation and democracy, fairness, and clarity of access).

We used equation 13, which has a range of 0 to 1 and is the same formula used by the UNDP for the human development index, to calculate all indices:

$$Index_{ij} = \sum_{i=1}^{k} (A_{ij} - Min_i)/(Max_i - Min_i) \ , \qquad (13)$$

where A_{ij} is the value of index component *i* for household *j* and Min_i and Max_i are the sample minimum and maximum for component *i*. The overall CPFM index is an average of the equally weighted institutional characteristics and management tools indices, which are themselves averages of more specialized indices that depend on specialized components weighted equally.

Our CPFM indices were based on perceptions of the survey respondents. We used perceptions for two reasons. First, in developing countries, stated policies often correspond poorly with on-the-ground management. Thus, perceptions of households have the potential to reflect reality better than stated policies. Second, developing “objective” measures of CPFM would require interviews with village leaders or forest managers, which may lead to poor information about the perceived details of CPFM and very limited variation in indices.

Table 2 CPFM Indices (aggregated and disaggregated)

Variable label	Mean	Std. dev.
Labor requirements	0.02	0.05
Social sanction	0.58	0.35
Penalty	0.52	0.33
Monitoring	0.53	0.34
Clarity of quota	0.21	0.24
Participation and democracy	0.49	0.29
Fairness	0.43	0.30
Clarity of access rules	0.33	0.21
Management tools	0.37	0.20
Institutional characteristics	0.41	0.22
Overall CPFM	0.39	0.20

Table 2 presents aggregated and disaggregated CPFM indices. We note in table 2 that the average overall CPFM index was 0.39, suggesting a relatively weak overall CPFM with considerable variation in perceptions of households. Indices for institutional characteristics and management tools were similar at 0.41 and 0.37, respectively. Mean sub-indices of the management tools index ranged from 0.02 (labor requirements) to 0.58 (social sanctions), and components of institutional characteristics ranged from 0.33 (clarity of access) to 0.49 (participation and democracy).

Descriptive statistics for other variables expected to be associated with tree growing are presented in table 3. The data came from subsistence rural households that mainly rely on a mixed crop–livestock farming system, with ox plowing and limited use of fertilizer. About 20 percent of households used improved stoves; the rest relied on three-stone fires. Households in the sample had an average of 1.15 hectares of land, 3.84 tropical livestock units, and a family size of 5.5. On average, households grew a relatively large number of trees on relatively limited land area—land which is also used for crop production for relatively large families.

Table 3 Descriptive Statistics on Other Correlates of Tree-Growing Behavior

Variable label	Mean	Std. dev.	Min.	Max.
Land size in hectares	1.15	1.02	0	6.02
Corrugated roof (1 if yes)	0.77	0.42	0	1
Livestock in TLU (tropical livestock units)	3.84	3.25	0	31.19
Gave loan in last year (1 if yes)	0.10	0.29	0	1
Fraction of boys (6–14 years)	0.15	0.15	0	0.67
Fraction of girls (6–14 years)	0.14	0.15	0	0.75
Fraction of female adults (>14 years)	0.32	0.19	0	1
Fraction of male adults (>14 years)	0.31	0.19	0	1
Family size	5.48	2.18	1	15
Max. years of education of a household member	5.14	3.71	0	16
Gender of head (1 if male)	0.83	0.38	0	1
Age of head in years	51.05	14.87	20	97
Years of education of head	0.81	2.21	0	12
Walking distance to town in minutes	82.76	58.32	0	280
Walking distance to road in minutes	38.42	37.25	0	180
Believes the land belongs to household	0.44	0.50	0	1
Expects to lose land in next 5 years (1 if yes)	0.19	0.39	0	1
Plants trees to ensure tenure security	0.17	0.37	0	1
Trusts people in village	0.67	0.47	0	1
Number of visits by DA	0.94	1.32	0	4
Farmer to farmer extension (1 if yes)	0.36	0.48	0	1
Uses improved stove (1 if yes)	0.20	0.40	0	1

About 17 percent of household heads in the sample were female. On average, in terms of number of years of education, household heads were much less educated (0.81 years) than the most educated member of the household (5.14 years). Land is owned by the government. The possibility of land redistribution exists and some households still perceived this possibility.

Current perceptions are fed by government-led land redistributions that took place over the past three decades, including one in our study area in 1997. Recently, farmers have been issued certificates confirming their right to use their land, and we found that about 44 percent of households believed land belongs to households. On the other hand, about 19 percent expected to lose their land due to possible village land redistributions within 5 years (after the survey). We also found that about 17 percent plant trees to ensure security of land tenure.

As an indicator of social capital, we used whether households reported that they trusted people in their villages—about 67 percent responded in the affirmative. While households have been visited by a development agent once on average, about 36 per cent of them have benefited from farmer-to-farmer extension.

Table 4 Correlation between Site Dummies and CPFM Indices (p-values in parentheses)

Site	CPFM index	Management tools index	Institutional characteristics index
Amanuel	0.141	0.0728	0.1596
	(0.0000)	(0.0267)	(0.0000)
D. Elias	-0.0464	-0.1470	0.0423
	(0.1671)	(0.0000)	(0.1776)
Kebi	-0.0996	-0.1577	-0.0315
	(0.003)	(0.0000)	(0.3159)
Wolkie	0.1449	0.1304	0.1481
	(0.0000)	(0.0000)	(0.0000)
Telma	-0.0167	0.0537	-0.0703
	(0.6197)	(0.1024)	(0.0248)
Sekladebir	-0.352	-0.3492	-0.3098
	(0.0000)	(0.0000)	(0.0000)
Godguadit	-0.1189	-0.038	-0.1565
	(0.0004)	(0.2474)	(0.0001)
Adismender	-0.0046	0.0423	-0.0409
	(0.8915)	(0.1989)	(0.1925)
Chorisa	0.2253	0.2588	0.1585
	(0.0000)	(0.0000)	(0.0000)
Adisgulit	0.0862	0.1066	0.0691
	(0.0101)	(0.0012)	(0.0275)

Table 4 presents correlation coefficients between dummies for sites included in the analysis and the three CPFM indices. P-values are in parentheses. We noted a number of negative and positive correlation coefficients, with many statistically significant at the 10-percent level or less, suggesting the presence of systematic variation in CPFM across the study sites. This result is similar to that found by Bluffstone et al. (2008). We also found a high and statistically significant degree of correlation between the different CPFM indices, suggesting that households had similar perceptions about the different components of CPFM indices (see appendix).

4. Econometric Approach and Results

We carried out the empirical analysis in two stages. The first stage involved analyzing the correlates of aggregated and disaggregated CPFM indices. Following recent literature, we considered CPFM institutions as endogenous (Heltberg 2001; Platteau and Abraham 2002; Baland and Platteau 1996). We then used these first stage estimation results to obtain predicted values of the various indices, which were used as explanatory variables in our second stage analyses. Four variables—number of years the household has farmed in the village, population size, population density per hectare, and area of forest in hectares—were used as excluded instruments.

In the second stage, we analyzed tree-growing behavior of households with a focus on the role of aggregated and disaggregated CPFM indices. Our dependent variables were whether households grew trees and the number of trees grown. We used two empirical models in the second stage—one for each of these two dependent variables. We ran probit models to analyze the determinants of the decision to grow trees (CPFM indices instrumented). The analysis of the determinants of the number of trees grown included Heckman's two-step procedure to take into account the possible bias that might arise due to exclusion of non-growers. This was in addition to using predicted values of CPFM indices from first stage regressions to take into account endogeneity of CPFM. We also bootstrapped standard errors.

In our analysis of tree-growing behavior, we were not able to include management tools and institutional characteristics indices in the same models due to the very high collinearity. This suggested that, in contrast with Bluffstone et al. (2008) who used the same method and found very low collinearity between the two sub-indices in the Bolivian Andes, in highland Ethiopia stark distinctions do not seem to exist between the two-index classifications; households that perceived high levels of institutional characteristics also tended to have better management tools.

Furthermore, as noted in the appendix, the individual components of institutional characteristics and management tools indices were collinear. We thus were unable to usefully include them in empirical models together, but—given the possibility of omitted variable bias—it also did not make sense to run regressions only with individual components (e.g., participation and democracy, access clarity, etc.) and not all others. We thus did not run individual CPFM component models. For each model, we present diagnostics at the bottom of each table. We noted that the variance inflating factor (VIF) was less than 10 for each model estimated, suggesting that multicollinearity was not a problem. Site dummies were included in all regressions to account for site-level idiosyncrasies, but the estimates are not reported to save space.

First stage regressions are presented in tables 5–7. Table 5 shows results for the overall CPFM index, as well as those for its two sub-indices—management tools and institutional characteristics indices. Tables 6 and 7 show, respectively, results for the five components of management tools (sanction, penalty, monitoring, clarity of quota, and labor requirements) and the three components of institutional characteristics (participation and democracy, fairness, and clarity of access rules). We reported robust standard errors for each regression. We also noted that the excluded instruments were significant, based on the Cragg-Donald weak instruments test.[5]

We see from table 5 that, among the excluded instruments used in the first stage, population density per hectare and area of forest in hectares had positive and statistically significant associations with each of the three indices reported in the table—the overall CPFM index, management tools index, and institutional characteristics index. These results suggested that sites with more dense population and more forest cover had better CPFM. On the other hand, population size had a negative and statistically significant association with these three indices, suggesting the positive contribution of smaller population size to CPFM. This finding corresponds with a variety of CPFM literature, going back indeed to Wade (1988).

We also see in table 5 that, while a number of explanatory variables included in the second stage were significant in one or more of the first stage regressions, three others—whether a household gave a loan in the last year, whether household believed they own their land, and whether they expected to lose land in the next five years—had positive and statistically significant associations with all three indices. These results suggested that those rich enough to make loans to others and those who felt more confident about their security of land tenure

[5] In particular, the results of the tests for each aggregated and disaggregated index as a dependent variable were as follows: overall CPFM index—F (4, 814) = 38.95; management tools index—F(4, 846) = 43.15; institutional characteristics—F(4, 935) = 27.44; sanction—F (4, 1008) = 23.10; penalty—F (4, 971) = 35.91; monitoring—F(4, 1005) = 35.68; clarity of quota—F (4, 929) = 20.45; labor requirements—F (4, 1026) = 6.41; participation and democracy—F (4, 998) = 25.39; fairness—F (4, 1016) = 13.49; and clarity of access rules—F (4, 964) = 27.83. For each regression (index,) the p-value is 0.0001 or smaller.

perceived more strict management of community forests. The results also suggested that households who perceived insecurity in land tenure in the near future had a perception of stricter CPFM.

In two out of three models, there were also positive relationships between CPFM indices on one hand and livestock owned and trust of village neighbors on the other, suggesting that endowments, such as animal and social capital, are important. We also found that in two models the size of land owned and use of improved stoves had negative and statistically significant relations with CPFM. The results of first stage regressions for each of the five components of management tools in table 6 and the three components of institutional characteristics in table 7 were similar to those in table 5 concerning the excluded instruments. However, the results were not always the same as for the included variables.

Table 5 Correlates of (First Stage Regressions) CPFM, Management Tools, and Institutional Characteristics Indices

	(1)	(2)	(3)
	CPFM index	**Management tools index**	**Institutional characteristics index**
Land size in hectares	-0.019	-0.023	-0.014
	(2.08)**	(2.56)**	(1.50)
Corrugated roof (1 if yes)	-0.007	-0.000	-0.007
	(0.40)	(0.01)	(0.37)
Livestock in TLU (tropical livestock units)	0.004	0.003	0.005
	(1.66)*	(1.27)	(1.99)**
Gave loan in last year (1 if yes)	0.047	0.057	0.035
	(2.43)**	(2.77)***	(1.71)*
Fraction of boys (6–14 years)	-0.015	-0.062	0.041
	(0.24)	(0.96)	(0.60)
Fraction of girls (6–14 years)	0.047	-0.001	0.106
	(0.72)	(0.01)	(1.53)
Fraction of female adults (> 14 years)	0.017	0.039	0.020
	(0.28)	(0.62)	(0.29)
Fraction of male adults (> 14 years)	0.053	0.031	0.081
	(0.85)	(0.49)	(1.17)
Family size	0.005	0.007	0.005
	(1.19)	(1.72)*	(1.07)

Maximum years of education of a household member	0.000	-0.000	-0.001
	(0.04)	(0.22)	(0.25)
Gender of head (1 if male)	0.028	0.033	0.021
	(1.40)	(1.69)*	(0.98)
Age of head in years	-0.000	-0.000	-0.001
	(0.57)	(0.33)	(0.97)
Years of education of head	0.000	0.002	-0.000
	(0.18)	(0.57)	(0.07)
Walking distance to town (in minutes)	-0.000	-0.000	-0.000
	(0.93)	(0.56)	(0.86)
Walking distance to road (in minutes)	0.000	0.000	-0.000
	(0.21)	(0.25)	(0.03)
Believes the land belongs to household	0.041	0.037	0.038
	(3.31)***	(2.90)***	(2.82)***
Expects to lose land next 5 years (1 if yes)	0.055	0.066	0.043
	(3.82)***	(4.43)***	(2.70)***
Trusts people in village	0.023	0.033	0.014
	(1.83)*	(2.51)**	(1.02)
Number of visits by development agent	0.001	0.006	-0.007
	(0.17)	(1.24)	(1.20)
Farmer-to-farmer extension (1 if yes)	0.002	-0.000	0.004
	(0.15)	(0.02)	(0.30)
Uses improved stove (1 if yes)	-0.030	-0.033	-0.025
	(1.98)**	(2.20)**	(1.47)
Years spent in farming in village	0.000	0.000	0.000
	(0.50)	(0.49)	(0.69)
Population density per hectare	0.036	0.045	0.027
	(6.71)***	(8.17)***	(4.67)***
Population size	-0.000	-0.000	-0.000
	(12.17)***	(12.08)***	(10.27)***
Area of forest in hectare	0.001	0.001	0.000
	(8.79)***	(10.40)***	(6.72)***
Constant	0.637	0.526	0.679
	(8.69)***	(6.87)***	(9.04)***
Observations	846	878	967
R-squared	0.27	0.29	0.22

Robust t statistics are in parentheses.

* significant at 10%; ** significant at 5%; *** significant at 1%.
Site dummies included but not reported.

Table 6 Correlates of (First Stage Regressions) Components of Management Tools

	(1)	(2)	(3)	(4)	(5)
	Sanction	Penalty	Monitoring	Clarity of quota	Labor requirements
Land size in hectares	-0.024	-0.037	-0.008	-0.017	-0.002
	(1.52)	(2.86)***	(0.55)	(1.54)	(1.18)
Corrugated roof (1 if yes)	0.013	0.013	-0.015	-0.011	-0.008
	(0.48)	(0.50)	(0.57)	(0.54)	(1.53)
Livestock in TLU (tropical livestock units)	-0.001	0.001	0.007	0.003	-0.000
	(0.33)	(0.35)	(1.83)*	(1.29)	(0.63)
Gave loan in last year (1 if yes)	0.081	0.055	0.106	-0.028	0.021
	(2.42)**	(1.66)*	(3.32)***	(1.04)	(2.54)**
Fraction of boys (6–14 years)	-0.293	-0.156	0.025	0.017	-0.011
	(2.65)***	(1.41)	(0.23)	(0.21)	(0.65)
Fraction of girls (6–14 years)	-0.111	-0.030	0.059	0.119	-0.014
	(0.98)	(0.26)	(0.56)	(1.52)	(0.85)
Fraction of female adults (> 14 years)	-0.087	0.001	0.060	0.075	0.013
	(0.81)	(0.00)	(0.56)	(0.94)	(0.79)
Fraction of male adults (> 14 years)	-0.068	-0.014	0.068	0.089	0.006
	(0.65)	(0.13)	(0.66)	(1.15)	(0.35)
Family size	0.011	0.008	0.008	0.003	0.004
	(1.64)	(1.15)	(1.30)	(0.65)	(3.11)***
Maximum years of education of a household member	0.002	0.000	-0.001	-0.000	-0.001
	(0.69)	(0.13)	(0.31)	(0.12)	(2.29)**
Gender of head (1 if male)	0.037	0.077	0.100	-0.016	0.006
	(1.21)	(2.55)**	(3.30)***	(0.66)	(1.43)
Age of head in years	0.000	-0.000	-0.001	-0.001	-0.000
	(0.09)	(0.51)	(0.79)	(1.79)*	(1.14)
Years of education of head	0.007	0.001	0.001	0.002	-0.001
	(1.23)	(0.20)	(0.31)	(0.44)	(1.10)
Walking distance to town (in minutes)	-0.000	-0.000	-0.000	-0.001	0.000
	(0.49)	(0.19)	(0.67)	(2.20)**	(0.59)

Walking distance to road (in minutes)	0.000	-0.000	0.000	0.001	-0.000
	(0.61)	(0.14)	(0.25)	(1.64)	(1.38)
Believes the land belongs to household	0.032	0.047	0.048	0.039	0.006
	(1.54)	(2.41)**	(2.39)**	(2.66)***	(1.87)*
Expects to lose land next 5 years (1 if yes)	0.061	0.074	0.047	0.070	0.004
	(2.45)**	(3.26)***	(1.93)*	(3.59)***	(0.80)
Trusts people in village	0.028	0.027	0.042	0.040	-0.008
	(1.33)	(1.33)	(2.10)**	(2.87)***	(2.13)**
Number of visits by development agent	0.013	0.008	-0.011	0.009	0.000
	(1.55)	(1.08)	(1.40)	(1.35)	(0.22)
Farmer to farmer extension (1 if yes)	-0.020	-0.010	0.035	-0.004	0.009
	(0.90)	(0.49)	(1.65)*	(0.29)	(2.16)**
Uses improved stove (1 if yes)	-0.068	-0.038	-0.014	-0.035	0.002
	(2.65)***	(1.55)	(0.57)	(2.05)**	(0.56)
Years spent in farming in village	-0.000	0.001	-0.000	0.001	0.000
	(0.47)	(0.56)	(0.24)	(1.99)**	(2.05)**
Population density per hectare	0.068	0.069	0.057	0.042	0.006
	(7.18)***	(8.30)***	(7.33)***	(5.60)***	(3.55)***
Population size	-0.000	-0.000	-0.000	-0.000	-0.000
	(8.15)***	(10.19)***	(10.89)***	(8.23)***	(3.70)***
Area of forest in hectare	0.001	0.001	0.001	0.000	0.000
	(8.69)***	(10.22)***	(9.58)***	(7.58)***	(3.32)***
Constant	0.792	0.677	0.727	0.368	0.024
	(6.26)***	(5.51)***	(5.96)***	(4.14)***	(1.38)
Observations	1040	1003	1037	961	1058
R-squared	0.22	0.25	0.24	0.21	0.16

Robust t statistics are in parentheses.

* significant at 10%; ** significant at 5%; *** significant at 1%

Site dummies are included but not reported.

Table 7 Correlates of (First Stage Regressions) Components of Institutional Characteristics

	(1) Participation and democracy	(2) Fairness	(3) Clarity of access
Land size in hectares	-0.012	-0.002	-0.018
	(0.94)	(0.13)	(2.15)**
Corrugated roof (1 if yes)	0.005	-0.026	-0.004
	(0.20)	(1.07)	(0.23)
Livestock in TLU (tropical livestock units)	0.010	0.002	0.003
	(2.97)***	(0.59)	(1.15)
Gave loan in last year (1 if yes)	0.026	0.015	0.050
	(1.00)	(0.47)	(2.51)**
Fraction of boys (6–14 years)	-0.102	0.182	0.023
	(1.07)	(1.95)*	(0.33)
Fraction of girls (6–14 years)	-0.027	0.251	0.080
	(0.27)	(2.66)***	(1.18)
Fraction of female adults (> 14 years)	-0.029	0.088	-0.028
	(0.30)	(0.95)	(0.42)
Fraction of male adults (> 14 years)	-0.015	0.124	0.086
	(0.17)	(1.34)	(1.30)
Family size	0.002	0.006	0.005
	(0.38)	(1.00)	(1.07)
Maximum years of education of a household member	0.002	-0.003	-0.001
	(0.68)	(0.94)	(0.38)
Gender of head (1 if male)	0.060	0.025	-0.010
	(2.16)**	(0.92)	(0.47)
Age of head in years	-0.001	0.000	-0.000
	(1.00)	(0.03)	(0.91)
Years of education of head	0.002	-0.005	0.003
	(0.43)	(0.99)	(1.06)
Walking distance to town (in minutes)	-0.000	-0.000	-0.000
	(0.20)	(0.90)	(1.37)
Walking distance to road (in minutes)	-0.000	0.000	-0.000
	(0.27)	(0.74)	(0.40)
Believes the land belongs to household	0.038	0.036	0.032

	(2.16)**	(1.95)*	(2.54)**
Expects to lose land next 5 years (1 if yes)	0.045	0.042	0.042
	(2.15)**	(1.88)*	(2.76)***
Trusts people in village	0.020	0.015	0.001
	(1.18)	(0.78)	(0.04)
Number of visits by development agent	-0.004	-0.005	-0.011
	(0.50)	(0.65)	(2.15)**
Farmer to farmer extension (1 if yes)	0.005	-0.007	0.010
	(0.25)	(0.36)	(0.76)
Uses improved stove (1 if yes)	-0.015	-0.059	-0.008
	(0.72)	(2.53)**	(0.53)
Years spent in farming in village	-0.000	0.000	0.001
	(0.44)	(0.08)	(1.65)
Population density per hectares	0.026	0.029	0.032
	(3.53)***	(3.77)***	(5.74)***
Population size	-0.000	-0.000	-0.000
	(10.01)***	(6.98)***	(9.96)***
Area of forest in hectares	0.000	0.000	0.000
	(6.49)***	(5.53)***	(6.51)***
Constant	0.896	0.575	0.572
	(8.63)***	(5.28)***	(7.95)***
Observations	1030	1048	996
R-squared	0.22	0.11	0.22

Robust t statistics are in parentheses.
* significant at 10%; ** significant at 5%; *** significant at 1%
Site dummies included but not reported.

Probit estimates are presented in table 8 with bootstrapped standard errors. The overall CPFM index and its two sub-indices (institutional characteristics and management tools indices) were included separately in three regressions (table 8). The results showed that the overall CPFM, institutional characteristics, and management tools indices had positive and statistically significant correlations with decisions to grow trees. The elasticities for these three indices were 5.2, 3.2 and 5.0, respectively. This suggests the role of better CPFM in increasing the probability that households grow trees on-farm, which in turn supports the results from our analytical model and the broader literature that caused us to expect better CPFM to influence household behavior.

Table 8 Determinants of the Decision to Grow Trees

	(1)	(2)	(3)
	CPFM index	Institutional characteristics index	Management tools index
Land size in hectares	1.043	0.566	1.293
	(3.26)***	(3.32)***	(3.28)***
Corrugated roof (1 if yes)	0.162	0.027	-0.200
	(0.89)	(0.19)	(1.61)
Livestock in TLU (tropical livestock units)	-0.102	-0.084	-0.067
	(1.40)	(1.22)	(1.11)
Gave loan in last year (1 if yes)	-2.076	-0.859	-2.679
	(2.39)**	(1.86)*	(2.62)***
Fraction of boys (6–14 years)	1.207	-0.969	3.700
	(1.96)**	(1.28)	(3.10)***
Fraction of girls (6–14 years)	-2.106	-3.289	0.353
	(2.01)**	(2.33)**	(0.66)
Fraction of female adults (> 14 years)	-0.895	-0.670	-2.062
	(1.27)	(1.01)	(2.17)**
Fraction of male adults (> 14 years)	-3.044	-3.027	-1.924
	(2.61)***	(2.54)**	(2.29)**
Family size	-0.279	-0.180	-0.395
	(2.74)***	(2.39)**	(2.80)***
Maximum years of education of a household member	0.036	0.061	0.066
	(1.81)*	(2.99)***	(3.06)***
Gender of head (1 if male)	-1.325	-0.604	-1.627
	(2.53)**	(2.03)**	(2.75)***
Age of head in years	0.022	0.025	0.016

	(3.57)***	(3.65)***	(3.66)***
Years of education of head	-0.050	-0.018	-0.115
	(1.90)*	(0.68)	(2.92)***
Walking distance to town (in minutes)	0.011	0.007	0.007
	(2.71)***	(2.51)**	(2.41)**
Walking distance to road (in minutes)	-0.004	-0.000	-0.004
	(1.43)	(0.07)	(1.61)
Believes the land belongs to household	-2.253	-1.402	-2.052
	(3.00)***	(2.94)***	(3.08)***
Expects to lose land next 5 years (1 if yes)	-2.817	-1.420	-3.429
	(2.84)***	(2.66)***	(2.94)***
Trusts people in village	-1.087	-0.350	-1.591
	(2.53)**	(1.78)*	(2.73)***
Number of visits by development agent	0.037	0.305	-0.238
	(0.75)	(3.23)***	(2.04)**
Farmer to farmer extension (1 if yes)	0.062	0.021	0.176
	(0.57)	(0.18)	(1.43)
Uses improved stove (1 if yes)	1.762	1.058	1.960
	(3.30)***	(3.14)***	(3.28)***
CPFM index	51.626	-	-
	(2.89)***	-	-
Institutional characteristics index	-	33.916	-
	-	(2.79)***	-
Management tools index	-	-	52.569
	-	-	(2.98)***
Constant	-22.548	-14.797	-21.704
	(2.92)***	(2.83)***	(3.01)***
Observations	1106	1106	1106
Pseudo R^2	0.17	0.17	0.17
Wald χ^2 (31)	145.86***	171.19***	126.56***

z statistics are in parentheses.

* significant at 10%; ** significant at 5%; *** significant at 1%

The dependent variable is 1 if the household grows trees and 0 if not. Site dummies are included but not reported. We used predicted values of CPFM index, institutional characteristics index, and management tools index from first stage regressions. Standard errors are bootstrapped.

Turning to explanatory variables other than CPFM indices, belief that land belongs to households and expectation of losing land in the next five years were both negatively associated with on-farm tree planting. This finding reinforces the notion that property rights can cut both ways when it comes to on-farm investments. Fraction of male adults, family size, male-headed household, being a lender, and trust of neighbors were also negatively associated with tree planting. Land size, maximum years of education of a household member, age of the household head, walking distance to town, and use of improved stoves had positive and statistically significant correlations with the decision to grow trees in all the three regressions.

As already noted, dealing inappropriately with households which do not grow trees could possibly lead to sample selection bias. We consequently used Heckman's two-step procedure and included the inverse Mills ratios estimated from first stage probit models as an additional explanatory variable. The inverse Mills ratios were significant at about 10 percent, suggesting the appropriateness of this approach. Standard errors were bootstrapped. Table 9 presents the results. As in the analysis of the decision to grow trees, we found that the overall CPFM as well as its two sub-indices (management tools and institutional characteristics) had positive and statistically significant associations with numbers of trees grown. The elasticities of number of trees grown with respect to the indices of overall CPFM, management tools, and institutional characteristics were, respectively, 12.8, 12.4, and 8.9. This suggested that households that perceive better CPFM, as reflected by these three indices, grow more trees. The interpretation of the results for the number of trees was the same as the probit models, except that the effects were interpreted in relation to the number of trees grown.

Table 9 Determinants of the Number of Trees Grown—Heckman's Two-Step Procedure

	(1)	(2)	(3)
	CPFM index	**Institutional characteristics index**	**Management tools index**
Land size in hectares	204.571	115.046	251.497
	(1.94)*	(1.99)**	(1.94)*
Corrugated roof (1 if yes)	26.470	1.080	-41.524
	(0.42)	(0.02)	(0.80)
Livestock in TLU (tropical livestock units)	8.626	12.029	15.331
	(0.35)	(0.52)	(0.68)
Gave loan in last year (1 if yes)	-363.753	-135.419	-476.892
	(1.32)	(0.89)	(1.41)

Fraction of boys (6–14 years)	494.493 (2.49)**	86.079 (0.37)	962.570 (2.34)**
Fraction of girls (6–14 years)	-8.349 (0.03)	-230.448 (0.50)	453.193 (2.22)**
Fraction of female adults (> 14 years)	-14.157 (0.07)	27.980 (0.13)	-233.213 (0.73)
Fraction of male adults (> 14 years)	-537.762 (1.34)	-534.560 (1.28)	-327.486 (1.08)
Family size	-40.231 (1.16)	-21.694 (0.88)	-61.961 (1.33)
Maximum years of education of a household member	8.688 (1.02)	13.347 (1.46)	14.327 (1.62)
Gender of head (1 if male)	-229.456 (1.47)	-93.964 (1.04)	-286.093 (1.50)
Age of head in years	5.576 (2.00)**	6.207 (2.05)**	4.458 (1.83)*
Years of education of head	-2.333 (0.22)	3.735 (0.37)	-14.381 (1.04)
Walking distance to town (in minutes)	2.186 (1.66)*	1.505 (1.41)	1.384 (1.41)
Walking distance to road (in minutes)	-2.512 (2.59)***	-1.876 (2.01)**	-2.612 (2.41)**
Believes the land belongs to household	-326.224 (1.36)	-166.428 (1.13)	-288.468 (1.35)
Expects to lose land next 5 years (1 if yes)	-480.879 (1.47)	-218.639 (1.29)	-595.818 (1.52)
Trusts people in village	-188.229 (1.33)	-49.945 (0.66)	-282.895 (1.41)
Number of visits by development agent	7.970 (0.43)	58.187 (1.72)*	-43.617 (1.11)
Farmer to farmer extension (1 if yes)	57.767 (1.15)	49.996 (1.01)	79.110 (1.50)
Uses improved stove (1 if yes)	424.200 (2.19)**	292.001 (2.47)**	461.340 (2.23)**
Inverse Mills ratio	758.706 (1.61)	758.706 (1.64)*	758.706 (1.58)
CPFM index	9,691.143 (1.67)*	- -	- -

Institutional characteristics index	-	6,366.636	-
	-	(1.64)*	-
Management tools index	-	-	9,868.092
	-	-	(1.68)*
Constant	-4,874.741	-3,419.844	-4,716.329
	(1.88)*	(1.94)*	(1.91)*
Observations	890	890	890
R-squared	0.14	0.14	0.14

z statistics are in parentheses.

* significant at 10%; ** significant at 5%; *** significant at 1%

Site dummies are included but not reported. We used predicted values of CPFM index, institutional characteristics index, and management tools index from first stage regressions. Standard errors are bootstrapped.

We see from table 9 that, in addition to the various CPFM indices, there are a number of other variables that influenced the number of trees grown. In particular, variables that had a positive and statistically significant effect on the number of trees grown in all the three regressions in table 9 were land size, age of the household head in years, and households that used improved stoves. Endowments and fuelwood conserving technologies, therefore, appear to be positively correlated with the number of on-farm trees planted. The only variable with a negative and statistically significant effect on the number of trees grown in all the three regressions was walking distance from homestead to road, suggesting that market and infrastructure access may spur on-farm tree investments. Three of these four variables were also statistically significant with the same signs in the corresponding probit regressions, suggesting—along with the CPFM results—that a number of the underlying determinants of whether to grow trees were not fundamentally different from the decision of how many trees to grow. We noted, however, that there were variables that influenced the decision to grow trees, but not the number trees. These were mainly associated with household characteristics, such as age-sex composition, size, and education, as well as property rights in land.

5. Conclusion

In this paper, we analyzed the determinants of aggregated and disaggregated indices of CPFM and the relationship between CPFM on the one hand, and the decision to grow trees and number of trees grown on the other. We found that while there was considerable variation across households, the average CPFM, institutional characteristics and management tools indices suggested low levels of management. We also found differences in CPFM management across sites that were likely driven by fundamentals, such as population size, population density, and size of forests.

The econometric results show that tree growing is very much influenced by the nature of community forest management. Indeed, overall CPFM, management tools, and institutional characteristics indices are positively correlated with the decision to grow trees on-farm and the number of trees grown. These results suggest that better social coordination between households dependent on common forests in low-income countries have profound effects on individual household behaviors. Tree planting on-farm is one example, and our findings broadly support those of others, including Nepal et al. (2007) and Mekonnen (2008). Bluffstone et al. (2008) applied a very similar methodology to household data from the Bolivian Andes and found that institutional characteristics and management tools indices were virtually uncorrelated with each other and that tree planting, while positively associated with the overall CPFM and institutional characteristics indices, was uncorrelated with management tools. Unlike in the Bolivian case, that the two sub-indices in Ethiopia —and indeed the individual components—appeared to be largely indistinguishable from each other suggests that synergies across CPFM aspects are what drive behavior. This finding also suggests that more fruitful, in-depth work could be done on the drivers of CPFM and the relationship between its components.

Indeed, several research questions remain. As the relationship between CPFM and on-farm tree planting is clarified, it is useful to evaluate whether relationships also exist with other technologies that could substitute for common forests. Such measures may include commercial fuels and improved agricultural inputs. Of perhaps critical importance to the long-term research agenda is to evaluate if, and under what circumstances, constraints imposed by reducing open access actually increase rural incomes. Evaluating policy instruments that increase rents and assure gains from better management reach all parts of households and societies is also critical.

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Appendix Correlation between Aggregated and Disaggregated CPFM Indices

	Overall CPFM	Manage-ment tools	Institutional character-istics	Labor require-ments	Sanc-tion	Penalty	Monitor-ing	Clarity of quota	Participation and democracy	Fair-ness	Clarity of access
Overall CPFM	1										
Management tools	0.93	1									
	(0.00)										
Institutional characteristics	0.94	0.77	1								
	(0.00)	(0.00)									
Labor requirements	0.70	0.72	0.62	1							
	(0.00)	(0.00)	(0.00)								
Sanction	0.79	0.93	0.57	0.58	1						
	(0.00)	(0.00)	(0.00)	(0.00)							
Penalty	0.84	0.96	0.64	0.67	0.96	1					
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)						
Monitoring	0.93	0.86	0.89	0.65	0.73	0.75	1				
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)					
Clarity of quota	0.73	0.73	0.63	0.64	0.56	0.69	0.51	1			
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)				
Participation and democracy	0.88	0.70	0.95	0.49	0.52	0.56	0.88	0.48	1		
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)			
Fairness	0.82	0.62	0.91	0.52	0.40	0.49	0.74	0.60	0.80	1	
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)		
Clarity of access	0.95	0.84	0.94	0.74	0.68	0.76	0.84	0.73	0.84	0.80	1
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	

* p-values in parentheses; predicted values of indices used.