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Nature and determinants of collective action for woodlot management in northern Ethiopia

Socio-economics and Policy Research

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Executive summary

Common property resources (resources owned and managed by a given community) are important sources of timber, fuel wood and grazing land in developing countries. However, unrestricted access by community members or ineffective use regulations result in overexploitation of the resources. Alternative solutions to the problem of overexploitation of these resources have been proposed including privatisation, state regulations and community collective action. Community resource management institutions and organisations to enforce them are now receiving greater attention as a viable alternative to privatisation and state regulations. However, there is inadequate evidence on the determinants of collective action and their effectiveness in managing common property resources in developing countries.

This paper evaluates the nature of community management of woodlots and identifies the determinants of collective action and its effectiveness in managing woodlots, based on a survey of 100 villages in the northern Ethiopian region of Tigray. Results are based on analysis of descriptive information to investigate the nature of community resource management and on econometric analysis to identify the determinants of collective action and its effectiveness.

Results show that although current benefits received by community members are limited, the woodlots contribute substantially to community wealth. Benefits from woodlots and average intensity of woodlot management are higher and problems of management less on woodlots managed at the village level compared with those managed at the higher municipality level. However, the level of woodlot management was not an important determinant of collective action or its effectiveness after controlling for other factors. The significant variables that explain collective action or its effectiveness include population density, proximity to markets and intervention by external organisations.

Community labour contribution for woodlot management increases with increasing population density up to a certain level after which it starts to decline, suggesting that there is an inverted U-shaped relationship between collective action and population density. This result indicates that land scarcity relative to labour encourages collective action up to an intermediate population density level, while the negative effects of incentive problems outweigh the positive effects on collective action when population grows to a higher level. Market access detracts from collective action suggesting that higher opportunity cost of labour and/or increased exit options undermine collective resource management. Despite the prevalent role of external organisations in initiating the establishment of community woodlots, involvement of external organisations reduced local effort to protect woodlots and tree survival, suggesting that the role of external organisations needs to be demand driven and complementary to local effort.

1 Introduction

Common property resources[1] are important sources of timber, fuel wood and grazing land in developing countries. Under unrestricted access by community members or ineffective use regulations, these resources are exploited on a first-come, first-served basis. Each individual user of the resource will tend to continue to utilise the resource until her average revenue is equal to the marginal cost of utilising the resource (Gordon 1954). This results in overexploitation of the resource and the scarcity rent of the resource becomes dissipated.

The solution to the problem of resource degradation in developing countries depends not only on appropriate technologies and efficient market prices, but also on local level institutions of resource management and the organisations that enforce them (Rasmussen and Meinzen-Dick 1995; Baland and Platteau 1996). Community resource management institutions and organisations are now receiving greater attention as a viable alternative to regulation by the state or privatisation as a means of rectifying inefficiencies caused by attenuated property right systems, externalities and other market failures.

However, devolving rights to local communities to help build institutions for common property management may not be a sufficient condition for sustainable use of such resources. Effectiveness in internal governance is needed for the effective application of community rules (Turner et al. 1994; Swallow and Bromley 1995). Hence, the need to identify factors that facilitate or hinder the development and effectiveness of local organisations becomes important.

In Ethiopia, rural communities depend primarily on common property resources for irrigation water, construction material, fuel wood and grazing land. Population pressure, market and government failures, and the absence or ineffectiveness of use regulations of common property resources have resulted in severe degradation of the resources. Perhaps as a result, Ethiopia has been identified as the country with the most environmental problems in the Sahel Belt (Hurni 1985).

Resource degradation is particularly severe in the northern region of Tigray. Soil erosion, soil nutrient depletion, moisture stress, deforestation and overgrazing are major environmental problems in the region (Fitsum et al. 1999). Currently, forests and woodlots cover less than 2% of the regional area (BoANRD 1995). The region depends almost entirely on imported construction material. Severe shortage of fuel wood has rendered rural communities increasingly dependent on animal dung for fuel, contributing to the problem of declining soil fertility (Berhanu 1998; Fitsum et al. 1999). Despite the fact that about 40% of the total land area is used for grazing (BoANRD 1995), shortage of feed sources is the major livestock production problem.

The Tigray region is known not only for severe resource degradation, but also for concerted efforts to redress the problem, especially since 1991. Major strategies of

1. Common property resources are defined as those resources that are owned and managed by a given community. They are contrasted with open access resources, which have no defined owner.

environmental rehabilitation include: construction of stone terraces, soil bunds and micro dams; establishment of area enclosures (areas enclosed from human and animal interference to promote natural regeneration) and community woodlots (enclosures with enrichment plantation of trees or areas of new plantation); and enforcement of grazing restrictions (Berhanu 1998). Since 1991, the role of local communities in resource management has been increasing, particularly in the management of area enclosures, woodlots and grazing lands. However, little evidence exists regarding the nature of local level institutions and organisations for resource management in Tigray, or their effectiveness. More generally, despite the extensive literature on common property resource management (Ostrom 1990; Bromley 1992), further empirical research is required to identify factors associated with collective action and its effectiveness in developing countries, since the effectiveness of collective resource management strategies is likely to be context specific (Runge 1992).

This paper seeks to add to the growing literature on common property resources in developing countries. The paper has two interrelated objectives. First, it evaluates the nature and impact of community management in the regeneration of woodlots in Tigray, considering the benefits to communities from these areas and problems encountered. Second, it uses econometric methods to investigate the determinants of collective action and its effectiveness in managing community woodlots.

2 The setting

The study area, Tigray, is found in northern Ethiopia on the Sudano-Sahelian drylands zone It covers an approximate area of 80,000 km^2, with a population of more than 3.3 million and annual population growth rate of 3%. The topography of the region is characterised as mountainous plateau and the climate as tropical semi-arid (Virgo and Munro 1978). Annual rainfall ranges from 450–980 mm with significant spatial and temporal variability (Berhanu 1998). Most of the precipitation falls within the three months of June, July and August, and with high intensity.

Agriculture is the mainstay of the economy of Tigray. More than 85% of the regional population depends on rainfed mixed crop-livestock subsistence agriculture, with oxen power supplying the only draft power for ploughing. Except for some areas in the Western and Southern Zones of the region which produce surplus during good rainfall years, the rest either produce just enough for subsistence during good rainfall years or face a chronic food deficit. The causes of the structural food deficit include severe environmental degradation, low soil fertility, inadequate and erratic rainfall, vulnerability to pests, lack of appropriate technology, small size and fragmentation of land holdings, lack of diversification in economic activities, lack of oxen for draft power and little use of modern inputs.

About 40% of the total area of the region is used for grazing (BoANRD 1995). Most of the crop residue is used as feed, fuel or construction material. Several areas of the highland plateau of Tigray are said to have been covered with forests at the turn of the century (Wolde-Giorgis 1993). Currently, forests and woodlots cover only about 1.6% of the area of Tigray (BoANRD 1995). Cutting trees for fuel, timber and agricultural implements, and clearing forests to expand agricultural land have exhausted the forest cover of the area. Forests, woodlots and grazing lands have been predominantly common property resources or open access resources in the region.

Since 1991, the Ethiopian government has embarked on an economic development strategy known as Agricultural Development-Led Industrialisation (ADLI), which places greater emphasis on agricultural development. Within the framework of the ADLI, regional administrations have been able to draw up economic strategies specific to their conditions. Conservation-based ADLI, which focuses on conservation of natural resources and popular participation, became the primary goal of economic development in Tigray. The natural resource conservation and development effort in the region has been aimed at improving the management of soil and water resources, environmental rehabilitation and protection through area enclosures and development of community woodlots, the development of irrigation through the construction of micro-dams and river diversions, and reforestation. Other elements in the regional ADLI include improvement of productivity in agriculture through improved agricultural practices and inputs, promotion of off-farm employment through diversification of the rural economy, and development of rural infrastructure.

The experience with area enclosures and community woodlots in Ethiopia during the previous military government was disappointing. Within the five years after the 1985 famine, more than 80 thousand hectares of hillsides were closed to most forms of use to foster the regeneration of indigenous plant species. By 1995, most of these enclosures and community woodlots were harvested or destroyed (Hoben 1995). The factors responsible for the poor performance of the environmental reclamation programme include inadequate scientific and technical knowledge, a standardised approach without regard to local agro-ecological conditions, and disregard of the views and interests of the rural population whom the programme was intended to serve. Programme implementation was top-down, authoritarian and politicised.

Prior to 1991, the experience with area enclosures and community woodlots in Tigray was limited. Since 1991, area enclosures and community woodlots in the region have been developed through a more participatory process. A development agent of the Bureau of Agriculture and Natural Resource Development (BoANRD), in collaboration with the local *tabia baito* (local administration council), identify the area to be closed and/or planted. The final decision is then made at a general meeting of the community members.

Site preparation for community plantations including construction of microbasins and terraces, and the digging of holes usually begins in late April of each year. Between 1992 and 1996, about 49 million seedlings are reported to have been planted in community woodlots (BoANRD 1996). The average survival rate is reported to have been around 40%, but can be as low as 10% in the lowland areas.

Guards who protect area enclosures or community woodlots are nominated from the local people and the community is expected to contribute for the payment of the guards. In areas where community contributions for guard payment are not forthcoming, site guards are allowed to either cut grass from the enclosure for private use or to graze animals. In some cases, government or non-governmental organisations pay for the guard through food-for-work programmes.

The area enclosures and community woodlots were established primarily for ecological regeneration rather than economic benefits. However, people's expectations of the economic benefits from these areas are increasing, which will present a major management challenge in terms of technical inputs and institutional arrangements for utilisation and distribution of benefits.

The development of community woodlots requires tree seedlings. Three types of tree nursery operate in Tigray: state, community and private (BoANRD 1996). Until 1996, about 210 state nurseries with an average land area of half a hectare and a potential to produce more than 390 thousand seedlings/year at full capacity had been operating in the region. State nurseries now sell seedlings to farmers. Community nurseries were launched in order to decentralise seedling distribution and reduce problems in seedling transportation. By 1996, about 446 community nurseries were operational with an average area of 0.04 hectares and a total capacity of 60 to 80 thousand seedlings/year. Community nurseries receive material and technical support from the BoANRD while the local community contributes labour and management. In addition to state and community nurseries, individual farmers raise their own seedlings, although on a limited scale.

Low survival rates and poor tree establishment in community woodlots appear to have encouraged a different tree planting arrangement in the region. Distribution of degraded communal lands, mostly gullies, for private tree plantation is now being practiced in the region. The initiative began in a village known as Echmare in Gulomekeda *woreda* (district) of the Eastern Zone of Tigray in 1992 (BoANRD 1996). The community, upon observation of the benefits of private tree plantation, took the initiative to divide communal land, in parcels of 3 m by 6 m, and to distribute it to individuals for tree plantation without requiring government approval. Later, this initiative was accepted by officials at the regional level and distribution of communal land for private tree plantation is now occurring in several *woredas* of the region.

There appears to be ambiguity in tree tenure rights in Tigray. Although a farmer has the ownership right to trees grown on his homestead and cultivated lands, he or she needs to get permission from the local *baito* to cut the trees. Regional laws also prohibit the planting of eucalyptus and cactus trees on cultivated land. The regional effort to plant trees has not been accompanied by proper incentives to encourage tree plantation by households or the community at large.

3 Theoretical framework

Let M represent collective management. We assume there is decreasing marginal benefit and increasing marginal cost of collective management (including the cost of monitoring and enforcing collective action). The benefit (*B*) and cost (C) functions can thus be specified as:

$$B(M) = aM - bM^2$$

$$C(M) = cM + dM^2$$

where *a*, *b*, *c* and *d* are positive constants. Collective management is affected by a vector of exogenous factors (X) which includes population density (PD), agricultural potential (AP), market access (MA), involvement of external organisations (EP), village level of management (versus municipality level) (LM), and size of the resource (SIZE). These exogenous factors are assumed to shift the marginal benefit and cost curves but do not affect the slope of the curves.[2] Incorporating the effect of the exogenous factors into the cost and benefit functions, we have:

$$(1) \quad B(M, X) = (\alpha X + \varepsilon_B)M - bM^2$$

$$(2) \quad C(M, X) = (\gamma X + \varepsilon_C)M + dM^2$$

where α and γ are coefficients to be estimated, and ε_B and ε_C are stochastic disturbance terms. Using the definitions of the exogenous factors, equations (1) and (2) can be rewritten as:

$$(3) \quad B(M, X) = \begin{bmatrix} \alpha_0 + \alpha_1 PD + \alpha_2 PD^2 + \alpha_3 AP + \alpha_4 MA + \\ \alpha_5 EP + \alpha_6 LM + \alpha_7 SIZE + \varepsilon_B \end{bmatrix} M - bM^2$$

$$(4) \quad C(M, X) = \begin{bmatrix} \gamma_0 + \gamma_1 PD + \gamma_2 PD^2 + \gamma_3 AP + \gamma_4 MA + \\ \gamma_5 EP + \gamma_6 LM + \gamma_7 SIZE + \varepsilon_C \end{bmatrix} M + dM^2$$

We assume that $\alpha_1 > 0, \alpha_3 > 0, \alpha_4 > 0, \alpha_6 > 0, \alpha_7 > 0$ and the signs of α_2 and α_5 are indeterminate and that $\gamma_1 < 0, \gamma_2 > 0, \gamma_3 \geq 0, \gamma_4 \geq 0, \gamma_5 < 0, \gamma_6 < 0, \gamma_7 > 0$.

Higher population density leads to greater scarcity of wood, hence greater marginal benefit of collective management of woodlots ($\alpha_1 > 0$). Higher agricultural potential increases the marginal benefit to managing woodlots as does better market access (α_3,

2. These factors may also shift the intercepts of the total benefit and cost curves, though this has no effect on the marginal benefits or costs, and hence no effect on optimal management.

$\alpha_4 > 0$). External programmes may increase the benefit of collective management by increasing awareness of profitable opportunities or of new technologies ($\alpha_5 > 0$), but they may undermine benefits if the programmes prevent communities from harvesting at the optimal time or otherwise undercut local institutions ($\alpha_5 < 0$). Local level management may increase benefits ($\alpha_6 > 0$), since local decision makers are likely to be more aware of local conditions affecting benefits. Greater size of the resource increases the benefit of collective management ($\alpha_7 > 0$). Economies of scale are assumed to reduce costs of monitoring and enforcing collective action as population density increases from a low level ($\gamma_1 < 0$), but at high population density, diseconomies of organising and enforcing agreements are assumed to dominate ($\gamma_2 > 0$). Higher agricultural potential or better market access may lead to higher labour opportunities and wages, hence higher costs of collective action ($\gamma_3 > 0$, $\gamma_4 > 0$), unless labour markets are so well integrated that local wages are not affected by local opportunities ($\gamma_3 = 0$, $\gamma_4 = 0$). External programmes are likely to help reduce the cost of organising and enforcing collective action ($\gamma_5 < 0$). Collective management organised at a more local level is likely to be easier (less costly) to enforce ($\gamma_6 < 0$). Costs of managing a resource are likely to increase with the size of the resource, though possibly at a diminishing rate because of economies of scale in management ($\gamma_7 > 0$).

Using equations (1) and (2), the necessary conditions for maximum are:

$$(5) \quad \frac{\partial B}{\partial M} = 0 = \alpha X - 2bM$$

$$(6) \quad \frac{\partial C}{\partial M} = 0 = \gamma X + 2dM$$

Combining equations (5) and (6) and rearranging terms we have:

$$(7) \quad M^* = \frac{\alpha X - \gamma X}{2(b+d)}$$

and

$$(8) \quad \frac{\partial M^*}{\partial X_i} = \frac{\alpha_i - \gamma_i}{2(b+d)}$$

Hence, we have the following comparative static results:

$$\frac{\partial M^*}{\partial PD} = \frac{\alpha_1 - \gamma_1 + 2(\alpha_2 - \gamma_2)PD}{2(b+d)} > 0$$ at low PD, since $\alpha_1 - \gamma_1 > 0$ and will be larger than $2(\alpha_2 - \gamma_2)$PD for low enough PD;

< 0 at high PD if $\alpha_2 - \gamma_2 < 0$ (e.g. if $\alpha_2 \leq 0$); and
> 0 at all PD if $\alpha_2 - \gamma_2 > 0$.

$$\frac{\partial M^*}{\partial AP} = \frac{\alpha_3 - \gamma_3}{2(b+d)} > 0,$$ if agricultural potential does not increase the opportunity cost of labour or provide more exit options, thus increasing the cost of enforcing collective action (i.e. $\gamma_3 = 0$).

$$\frac{\partial M^*}{\partial MA} = \frac{\alpha_4 - \gamma_4}{2(b+d)} > 0,$$ if market access does not raise opportunity cost of labour or provide more exit options ($\gamma_4 = 0$).

$$\frac{\partial M^*}{\partial EP} = \frac{\alpha_5 - \delta_5}{2(b+d)} > 0,$$ if external organisations do not undermine benefits ($\alpha_5 > 0$).

$$\frac{\partial M^*}{\partial LM} = \frac{\alpha_6 - \gamma_6}{2(b+d)} > 0$$

$$\frac{\partial M^*}{\partial SIZE} = \frac{\alpha_7 - \delta_7}{2(b+d)} > 0,$$ if economies of scale reduce cost of management relative to benefits ($\alpha_7 > \gamma_7$).

4 Research methods and hypotheses

4.1 Methods

This study was based on a survey of 50 *tabias* (the lowest administrative unit in Tigray, comprising usually four or five villages) in the highlands[3] of Tigray in the 1998–99 cropping season. Sample *tabias* were selected based on random sampling stratified by proximity to a market town and presence of an irrigation project. Within each *tabia*, two villages were selected randomly. A semi-structured questionnaire was administered with representative individuals at both (*tabia* and village) levels. Each interview involved 10 respondents chosen to represent different age groups (<30 years old and >30 years old), villages (representation of each sample village), primary occupations (farming or off-farm) and gender. The survey collected information about changes in agricultural and natural resource conditions between 1991 and 1998, and their causes and effects.

Analysis of descriptive information from the survey was used to identify the nature of the management of woodlots, the roles of different organisations (local and external) in managing them, and the benefits and problems encountered. Econometric analysis was used to investigate the determinants of collective action and its effectiveness in managing woodlots. The indicators of collective action and effectiveness used in the econometric analysis include: the amount of uncompensated collective labour/hectare invested in managing the woodlot; whether the community paid for a guard to protect the woodlot; whether there were any violations of the restrictions on use of the woodlot; the number of trees planted/hectare on the woodlot since its establishment; and the survival rate of the trees planted.

The type of regression model used depends on the nature of the dependent variable. In this study, a Tobit model was used to explain collective labour investment and tree survival rate, since these variables are left-censored at zero. Binary Probit models were used to explain whether the community paid for the guard or whether there were violations of restrictions, since these are binary variables. Least squares regressions were used for tree planting density, since this variable is not censored. In all regressions, coefficients and standard errors were corrected for the sampling weights and stratification, and the standard errors were robust to heteroskedasticity and non-independence of multiple observations from the same primary sampling unit (*tabia*).

4.2 Hypotheses

The factors used to explain variations in collective action and its effectiveness included population density, access to market, agricultural potential, the presence of external organisations, whether the woodlot was managed at the village or *tabia* level and the area of the woodlot. Our hypotheses about how these factors may influence collective action

3. Highlands are defined as those areas >1500 masl

draw from the literature on induced institutional innovation and collective action in managing common property resources (Boserup 1965; Olson 1965; Hayami and Ruttan 1985; North 1990; Rasmussen and Meinzen-Dick 1995; Baland and Platteau 1996; Otsuka and Place 1999; Pender 1999; Pender and Scherr 1999). At low levels of population density, the demand for collective action to manage resources will be low and the organisational costs of attaining is high. As population density grows, increasing land scarcity will increase the benefits of improved resource management, whether through collective action or development of private property. This may induce increased collective action, particularly if economies of scale or high exclusion costs favour collective over private management. However, as population density grows to very high levels, the gains from collective action may be outweighed by the incentive problems associated with it, as rising scarcity increases the benefits from attempting to 'free-ride' on the efforts of others. The economies of scale of collective action may diminish or be replaced by diseconomies of scale at higher population densities. As a result, the net benefits of collective action may stabilise or even decline while the net benefits of privatisation continue to increase with increasing population density. Thus, there may be an 'inverted U-shaped relationship' between collective action and population density, with higher levels and effectiveness of collective action at an intermediate population density than at a very low or very high density (Pender 1999).

Access to markets may also have mixed effects on collective action. On one hand, having better access to markets increases the value of resources and thus the value of managing resources well, which may favour collective action. On the other hand, better market access may tend to undermine individuals' incentives to co-operate by increasing the opportunity cost of labour or by offering more 'exit' options, making it more difficult to punish those who fail to co-operate (Baland and Platteau 1996; Pender and Scherr 1999). Thus, the impact of market access on collective action can only be determined empirically. Agricultural potential may have mixed impacts on collective action for similar reasons.

The presence of external organisations may favour collective action when those organisations are seeking to provide complementary inputs to local collective inputs, but may undermine collective action if external organisations are providing substitutes for collective action or are otherwise undermining collective action (such as by increasing the 'exit options' of local community members, as noted above) (Pender and Scherr 1999).

We expect that collective action is easier to obtain and likely to be more effective when co-operation of a smaller number of people is needed, when the beneficiaries are a more homogenous and stable group, and when the benefits received by these people are more apparent (Olson 1965; Rasmussen and Meinzen-Dick 1995; Baland and Platteau 1996). Thus, we expect that collective action will be more prevalent and more effective for village-managed woodlots than for *tabia*-managed woodlots, since villages are smaller, more cohesive and a more stable unit than *tabias* (e.g. the *tabias* were reorganised in 1995 to include more villages) and since, as noted below, the benefits accruing to community members from village-managed woodlots have been greater than the benefits from *tabia*-managed woodlots.

To the extent that economies of scale are important in favouring collective action (for example, in protecting the woodlot), we expect that collective action should be greater and more effective on larger woodlots.

5 Results

5.1 Descriptive analysis

Almost 9 out of 10 *tabias* in the highlands of Tigray had woodlots (Table 1). On average, there were nine woodlots/*tabia* and these averaged about eight hectares in size, although there was much variation in numbers and sizes of woodlots across communities. Most of the woodlots had been established since the fall of the former Derg government in 1991. The establishment of most woodlots had been promoted by external organisations, usually the Tigray Regional BoANRD. In a few cases, non-governmental organisations, including the Relief Society of Tigray (REST) or World Vision, were involved.

Table 1. *Characteristics of community woodlots, means (standard errors in parentheses).*[a]

Item	Village-managed	*Tabia*-managed	All woodlots
Percentage of *tabias* with a woodlot	57.7 (8.1)	29.9 (7.2)	87.6 (5.8)
Number of woodlots/*tabia*	7.2 (1.3)	0.9 (0.2)	9.0 (1.3)
Area of woodlots (hectares)	5.1 (0.9)	18.5 (3.8)	7.9 (1.4)
Percentage of woodlots established since 1991	75.6 (8.8)	91.3 (5.2)	78.0 (7.6)
Percentage of woodlots promoted by a programme or organisation	94.6 (3.8)	98.7 (1.4)	95.5 (3.0)
Promoted by BoANRD	76.5	91.4	79.5
Promoted by REST	4.6	0.0	3.7
Promoted by BoANRD and REST	4.8	7.3	5.3
Promoted by World Vision	4.8	0.0	3.8
Percentage of woodlots where users are:			
All *tabia* members	0.0 (0.0)	94.8 (5.3)	19.6 (6.4)
Only village members	100.0 (0.0)	0.0 (0.0)	79.1 (6.4)
Only the guard	0.0 (0.0)	5.2 (5.3)	1.1 (1.1)

a. Means and standard errors are corrected for sampling stratification and weights.

Most woodlots were managed at the village level by the village council and were used only by members of that village. However, about one third of the *tabias* that had woodlots managed them at the *tabia* level, in which case the *tabia* council was responsible for management. In almost all cases, all members of the *tabia* were allowed to use the *tabia*-managed woodlots, though in a few cases, only the guard was allowed to use the woodlot. *Tabia*-managed woodlots tended to be larger than village-managed ones, averaging >18 hectares in size compared with about five hectares for village woodlots.

The most commonly allowed use of woodlots was the cutting and collecting of grass for animal feed, roof materials or other purposes (Table 2). Collecting fruits and beekeeping in woodlots were also commonly allowed. These uses were more common on village-managed than *tabia*-managed woodlots. Most other uses, including cutting trees, shrubs, branches or roots, and collecting fuel wood, bark, leaves or dung, were not allowed in woodlots. In a few cases, animals were allowed to graze in the woodlot, but only during a drought. Woodlots were protected in almost all cases by a guard paid in

Table 2. *Allowed uses of community woodlots, percentage of woodlots (standard errors in parentheses).*[a]

Use	Village-managed	*Tabia*-managed	All woodlots
Grazing	0.6 (0.6)	8.9 (5.7)	2.3 (1.3)
Cut and remove grass	71.1 (9.5)	39.9 (15.0)	64.7 (8.3)
Collect fuel wood	4.4 (3.9)	0.0 (0.0)	3.5 (3.1)
Collect dung	1.0 (1.0)	0.0 (0.0)	0.8 (0.8)
Cut and remove trees or branches	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Cut and remove shrubs	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Collect leaves	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Collect bark	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Collect roots	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Collect fruits or seeds	60.0 (9.4)	49.1 (15.4)	57.8 (8.4)
Beekeeping	61.1 (9.6)	38.4 (14.2)	56.4 (8.4)

a. Means and standard errors are corrected for sampling stratification and weights.

cash or in kind. In some cases, the guard was compensated by being allowed to collect grass from the woodlot. For most village-managed woodlots, the village residents paid the guard; while for *tabia*-managed woodlots, external organisations such as BoANRD and REST were more involved. Thus, it was more common for the local community to hire the guard for village-managed than for *tabia*-managed woodlots (Table 3).

Table 3. *Indicators of collective action to manage woodlots, means (standard errors in parentheses).*[a]

Indicator	Village-managed	*Tabia*-managed	All woodlots
Number of labour days/hectare invested in the woodlot in 1998	152.23 (35.86)	231.75 (203.7)	164.75 (65.90)
Percentage of woodlots protected by a guard hired by the community	54.4 (10.9)	28.2 (10.3)	49.0 (9.2)
Percentage of woodlots where violations of restrictions occurred in 1998	19.5 (5.8)	35.8 (12.0)	22.8 (5.4)
Density of trees planted/hectare	5205 (2372)	1814 (511)	4453 (1837)
Percentage survival rate of trees	61.6 (5.8)	71.1 (9.6)	63.7 (5.1)

a. Means and standard errors are corrected for sampling stratification and weights.

Violations of restrictions were usually punished by a cash fine set by the community council, though in many cases fines were decided by the local court. The most common violations of restrictions in 1998 were cutting grass, grazing animals, and cutting trees or branches. Violations were more common on *tabia*-managed woodlots. Fines were typically less than 100 Ethiopian birr (EB) (US$ 1 = EB 7.14 in 1998) for cutting grass or grazing, but could be much higher for cutting trees. In some cases a fine of as much as EB 500 and imprisonment were imposed for cutting trees.

Given the limited allowed uses of the woodlots, the benefits received were, unsurprisingly, small. Of 164 village-managed woodlots in our sample, it was reported that benefits were received in 1998 from only 57 woodlots, mainly from cutting grass. On average, fewer than half of the households in the villages benefited from grass cutting and in 1998, the average estimated value of benefit was EB 2783/woodlot, only about EB 2/capita in the villages where benefits were received. The benefits from *tabia*-managed woodlots were even lower, averaging only EB 352/woodlot, less than EB 0.10/capita.

Both local and external organisations played important roles in managing the woodlots. The most important local organisation was either the *tabia* or the village council, depending on which level managed the woodlot. These organisations were involved in organising and encouraging participation in woodlot development, developing rules and regulations, and financing the guard. The most important external organisation was the BoANRD, which was involved mainly in providing material support (including seedlings) and technical assistance.

Villages were pursuing a more intensive strategy of woodlot management than *tabias*. Labour for tree planting, construction of soil and water conservation structures, weeding and harrowing was the main collective input, averaging 0.18 person-days/capita for village-managed woodlots and 0.13 person-days/capita for *tabia*-managed woodlots. Village woodlots were also planted much more densely than *tabia* woodlots. The average tree survival rate was somewhat higher for *tabia* woodlots, but considering the differences in planting densities, the number of surviving trees/hectare was still much higher on village woodlots. Considering the average returns/capita reported above, the average return/person-day invested in 1998 was about EB 10 for village-managed woodlots (comparable with the daily wage rate in rural Tigray), but less than EB 1 for *tabia*-managed woodlots.

Of course, the main benefit of a woodlot is not the value of grass collected, but the value of the trees in the woodlot, a non-liquidated capital gain. The most commonly planted trees in community woodlots are eucalyptus trees (especially *E. globulus* and *E. camaldulensis*). The average price of eucalyptus poles in the highlands of Tigray was about EB 28/pole in 1998 (Jagger and Pender 2000). Considering the average planting density (about 4500 trees/hectare) and survival rate (64%) reported in Table 3, a woodlot of average-sized eucalyptus trees would be worth more than EB 80,000/hectare on average and much more in places where wood is very scarce. With an average of more than 70 hectares of woodlots/*tabia* (9 woodlots averaging almost 8 hectares each), this represents a substantial contribution to the wealth of communities in Tigray (averaging more than EB 5 million/community).

Thus, despite the limited amount of current benefit that people are receiving from community woodlots in Tigray, community members are generally satisfied that they will benefit from them eventually. Only a small fraction of communities reported uncertainty about future benefits as a problem, though the problem was more commonly reported for *tabia*-managed than village-managed woodlots. The survey also enquired about other possible problems caused by woodlots including reduction in grazing area, reduced availability of wood, pests, conflicts over use and fire hazards. Most of these problems were generally regarded as minor or non-existent. In some communities, however, less grazing area, less availability of wood and pests were seen as major problems. In almost all cases, community members reported that the condition of the area where the woodlot was established had improved substantially as a result of the protection and investment in developing the woodlot.

Scarcity of fuel wood is a critical problem in many communities, mainly due to the deforestation that has occurred over many years. In the recent past, however, this scarcity may have been aggravated by restrictions on collecting fuel wood from woodlots. For example, 13 of the 100 sample villages reported that fuel wood had declined in rank as a source of fuel for cooking since 1991 (none reported an increase in importance of fuel wood) and in all of these cases, shortage of fuel wood was cited as the reason for the change. In 11 of these cases, the rank of dung as a fuel source had increased and in several cases, burning of crop residues had increased in importance (the rank of these sources did not change in other villages). Thus, even though restrictions on using woodlots are leading to improved conditions of the woodlots, they may be contributing to declining soil fertility in the near term as dung and crop residues are increasingly used for fuel, rather than being recycled to the soil.

To summarise the descriptive analysis, we found that woodlots were contributing substantially to the wealth of communities in Tigray, even though the near-term benefits were limited due to restrictions on use. We found that village-managed woodlots were more common and smaller than *tabia*-managed woodlots, and provided more near-term benefits; moreover, community members invested more effort in managing them, there are fewer violations of restrictions in the village woodlots, they were planted much more densely and the number of surviving trees/hectare was also higher, despite somewhat lower survival rates/tree planted in the village woodlots.

In the next section, we test whether there are statistically significant differences in the management and survival of trees on village vs. *tabia* woodlots, controlling for other factors, as well as the other hypotheses presented earlier about factors affecting woodlot management.

5.2 Econometric analysis

The initial econometric results are presented in Table 4. Dummy variables were included for the different zones of Tigray to proxy for differences in agro-climatic potential (the Southern and Western Zones have generally higher potential, due to better soils and irrigation in the Southern Zone and higher rainfall in the Western Zone), as well as other differences between these zones (e.g. differences in enforcement of restrictions on woodlots by zonal and *woreda* authorities). We included population density and population density squared to test for an inverted U-shaped relationship between population density and collective action. Market access was represented by distance to the *woreda* (district) town, which was usually where farmers marketed their produce and purchased inputs. The effect of external organisational presence was investigated by including a dummy variable indicating whether the woodlot was promoted by an external organisation. Another dummy variable reflected whether the woodlot was village-managed or

Table 4. *Determinants of collective action and its effectiveness on community woodlots, 1998*[a] *(t-statistics in parentheses).*

Explanatory variable	Collective labour input (person-days/hectare)	Whether community pays for guard	Whether any violations of restrictions occurred	Number of trees planted/hectare	Survival rate of planted trees (%)
Central Zone (cf. Southern Zone)	-1541.292 (-2.439)	-1.258 (-1.673)	-0.437 (-0.043)	-11374 (-2.168)	18.03 (1.856)
Eastern Zone (cf. Southern Zone)	-928.882 (-1.810)	1.060 (1.682)	-1.509 (-3.845)	2288 (0.283)	17.50 (1.917)
Western Zone (cf. Southern Zone)	-1442.685 (-1.523)	0.363 (1.013)	-1.029 (-1.139)	6853 (0.171)	5.24 (1.302)
1994 population density/km^2	36.545 (2.148)	0.0110 (0.026)	-0.0122 (-0.678)	-249.3 (-2.346)	0.0085 (0.798)
1994 population density^2	-0.1023 (-2.106)	-0.0000601 (-0.371)	0.0000387 (1.146)	0.693 (2.395)	-0.000255 (0.961)
Distance to *woreda* town (km)	16.0929 (-2.103)	-0.00462 (-1.563)	-0.00623 (-0.264)	241.5 (2.063)	0.350 (3.803)
Woodlot promoted by external organisation	1148.053 (1.543)	-1.286 (-3.011)	0.0870 (1.346)	5505 (1.231)	-5.573 (-4.635)
Woodlot managed by village (cf. managed by *tabia*)	-615.094 (-1.066)	0.668 (0.678)	-0.158 (-0.769)	5114 (0.097)	7.712 (1.521)
Area of woodlot (hectares)	-28.1209 (-1.175)	-0.0122 (-1.023)	0.00500 (1.034)	-278.3 (-1.514)	0.426 (0.039)
Intercept	-3639.085 (-2.151)	0.842 (1.132)	0.900 (1.167)	12067 (1.034)	38.95 (2.139)
Type of regression	Tobit	Probit	Probit	Least squares	Tobit
R^2/pseudo R^2	0.231[b]	0.273[c]	0.136[c]	0.525	0.436[b]
Number of positive observations/total observations	66/223	110/219	53/219	76/76	73/76[d]

a. All regression results are corrected for sampling stratification and sampling weights, and standard errors are robust to heteroskedasticity and non-independence within the primary sampling units (*tabias*).
b. R^2 for least squares regression on the same data.
c. Pseudo R^2 values.
d. Planting density and survival data were not collected for all woodlots in the sample.

tabia-managed. Finally, the size of the woodlot was included to investigate whether there were economies (or diseconomies) of scale in woodlot protection and management.

We found that the intensity of management of woodlots (labour input, community contribution to protection, and planting density) was lowest in the Central Zone of Tigray, while survival rate was highest in this zone (controlling for other differences between zones). This suggests that a less intensive approach to woodlot management is being pursued in the Central Zone, but that this can be consistent with higher survival rates (though lower density of surviving trees), probably because of less competition among trees for water, sunlight and nutrients in the less densely planted woodlots. Community labour input was also lower in the Eastern Zone than in the Southern Zone, but community contributions to protecting woodlots were greater, leading to fewer violations of restrictions and higher survival rates. Thus, the approach to community woodlots in the Eastern Zone appeared to be oriented towards less labour intensity of management but greater effort to protect the trees, with favourable impact on tree survival. We found no significant differences in tree management, protection or survival between the Western and Southern Zones.

We found that the labour intensity of woodlot management was positively associated with population density, but negatively associated with population density squared; this is consistent with the hypothesis of an inverted U-shaped relationship between population density and collective action. The turning point in this relationship (where maximum predicted collective labour input occurs) was at 179 persons/km^2, well within the range of population density observed in Tigray (the range in our sample was from 39 to 302 persons/km^2).[3] The magnitude of the impact of population density was also substantial: an increase of population density from 40 to 50 persons/km^2 would increase predicted labour input/hectare by 273 labour days (much more than the average labour input/capita on woodlots which is 164 labour days/hectare).

Other indicators of collective action and its effectiveness—including whether the community pays for a guard, violations of restrictions and survival rate of trees—also showed a relationship consistent with the inverted-U hypothesis (with the signs of the coefficients reversed for violations of restrictions), though these relationships were statistically insignificant. Unexpectedly, there was a statistically significant U-shaped relationship between planting density and population density, with planting density first falling and later rising as population density increased (the turning point was at 180 persons/km^2). It may be that lower planting density at moderate population density is a result of collective action, i.e. a decision by communities to not overexploit the woodlot area by restricting the planting density. If this is the case, then this relationship also supports the hypothesis of an inverted U-shaped relationship between collective action and population density. However, this is only an *ex post* hypothesis to explain a result that we did not expect, and further research would be needed to confirm or reject this hypothesis.

With regard to market access, we found that communities that were more remote provided greater collective labour input, planted trees more densely and obtained higher

3. Summary statistics of the variables used in the regressions are presented in Annex I.

tree survival rates. These results were both statistically and quantitatively significant; being 10 km further from the *woreda* town increased predicted labour input by 16 labour days/hectare (one-tenth of average labour input), predicted planting density by 2400 trees/hectare and tree survival by 3.5 percentage points. These findings are consistent with the argument that improved market access undermines collective action by increasing labour opportunity costs and/or giving people more exit options from the community.

The presence of external organisations, as indicated by whether the woodlot was promoted by an external organisation (usually the BoANRD), had negative associations with whether the community paid for a guard and with tree survival. The negative association with community payment for a guard, probably results from the fact that external organisations often pay for the guard, as discussed earlier, reducing the need for this aspect of collective action. This is similar to the results of Pender and Scherr (1999) in Honduras, where external government organisations were found to displace local collective action. The negative association of external promotion with tree survival suggests that external programmes may not be achieving full participation of local communities in promoting woodlots. Part of the problem may be that local communities often prefer to plant eucalyptus trees, which survive well and grow rapidly under the uncertain rainfall of Tigray, whereas external organisations sometimes promote other species that may be less hearty or less preferred by local households (Jagger and Pender 2000).

Contrary to our expectations, collective action was not significantly greater or more effective on village-managed woodlots than on *tabia*-managed woodlots, after controlling for other factors. This may be because differences in benefits, community stability or cohesiveness between the *tabia* level and the village level were relatively small; other factors, such as population density, market access or external organisations may be more responsible for the differences in collective action found on different woodlots. The area of the woodlot also had a statistically insignificant impact on our measures of collective management of woodlots and its effectiveness. This suggests that economies or diseconomies of scale in woodlot management are weak.

A possible alternative explanation for the weak influence of some variables is that there may be multicollinearity among the explanatory variables. We tested for problems of multicollinearity and found potential problems only between the population density and density-squared variables. The correlation between these variables was almost 0.98, leading to high variance inflation factors for these variables (Chatterjee and Price 1991). However, both variables were included in the models since they have statistically significant coefficients. Moreover, omitting one of the variables would result in omitted variable bias. None of the other explanatory variables had a variance inflation factor >3, indicating that multicollinearity was not a major concern for these variables (Chatterjee and Price 1991).

6 Conclusion and implications

Collective action in managing woodlots generally functions well in Tigray, which supports the role of community resource management in redressing resource degradation. Despite the fact that the community benefits in 1998 were limited due to various restrictions on use of the woodlots, the woodlots contribute substantially to community wealth; community members are generally satisfied with the woodlots as a reserve of natural capital.

Benefits were greater and reported problems of managing the woodlots were less on woodlots managed at the village level than on those managed at the higher *tabia* level. Communities that managed woodlots at the village level applied greater labour inputs, planted trees much more densely, more often hired a guard and less often had violations of restrictions. Although average tree survival (per tree planted) was lower on village-managed woodlots, the number of trees surviving/hectare was greater in village woodlots. Most of these differences were not statistically significant after controlling for other factors, suggesting that other factors besides the level of management are more important in determining the extent and effectiveness of collective management of community woodlots. However, village-level management of community woodlots has superior economic significance.

We found some support for the hypothesis of an inverted U-shaped relationship between population density and collective action, especially with respect to collective labour input. However, many of the findings with respect to population density were weak statistically and some suggested that population pressure can undermine collective action (especially the contribution to protection of woodlots) even at lower levels of population density.

We found that access to markets appears to undermine the intensity of collective management of woodlots and its effectiveness in ensuring tree survival, probably because this increases the opportunity costs of people's time and/or the 'exit options' of community members. Promotion of woodlots by external organisations appears to displace local collective action in protecting the woodlot and contributes to lower tree survival rates.

Our findings imply that collective action can be an effective means of redressing resource degradation and increasing community wealth. However, they also suggest that the effectiveness of collective action may be undermined by restrictions that limit the benefits of woodlots to local communities, by promotional efforts that displace local initiatives or promote planting of trees that are less acceptable to local communities, or by management at a higher administrative level. Community management of woodlots (and perhaps other natural resources) is likely to be more effective if conducted at the lowest level consistent with concerns about distributional issues and externalities, and if external interventions respond to local concerns and priorities rather than being imposed.

Our findings suggest that collective woodlot management is likely to be more intensive and effective in communities that are more remote from markets or that have low to moderate population densities. In such communities, which are often in lower potential areas where agricultural development is difficult to achieve, development and management of community woodlots may be a key element of an effective development strategy. In areas of greater market access or high population density, private-oriented approaches to resource management may be more effective.

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Annex I. Summary statistics of variables used in regressions

Variable	Number of observations	Mean[a]	Standard error[a]	Minimum	Maximum
Labour days/hectare	223	164.76	65.90	0	10,800
Whether community hires a guard	223	0.490	0.092	0	1
Whether violations of restrictions occurred	223	0.228	0.054	0	1
Number of trees planted/hectare	80	4453	1837	333	51,750
Tree survival rate (%)	80	63.7	5.1	0	97.5
Southern Zone	233	0.141	0.049	0	1
Central Zone	233	0.423	0.100	0	1
Eastern Zone	233	0.397	0.100	0	1
Western Zone	233	0.039	0.019	0	1
1994 population density/km^2	225	154.9	14.7	39.5	301.7
Distance to *woreda* town (km)	229	27.6	5.0	0	87
Woodlot promoted by external organisation	227	0.949	0.233	0	1
Woodlot managed by village (cf. managed by *tabia*)	227	0.799	0.063	0	1
Area of woodlot (hectares)	227	7.76	1.34	0.13	100

a. Means and standard errors are corrected for sampling stratification and weights.

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