Collective action for grazing land management in mixed crop–livestock systems in the highlands of northern Ethiopia

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Executive summary

Communal grazing lands are important sources of feed in developing countries. The uncontrolled and free grazing system prevalent in many developing countries has caused sever degradation of the grazing lands. Several alternative management options have been recommended to solve the degradation of common property resources, including state ownership, imposition and enforcement of use rules and regulations by external organisations such as the government, private ownership and community resource management. This paper examines the nature and determinants of collective action for grazing land management in the highlands of Tigray, northern Ethiopia.

Results are based on a survey of 100 villages in 1998–99. Indicators of collective action used in the study include area of grazing land under use rules and regulations per household, whether community pays for guard to protect the grazing land, average value of household contributions for grazing land management, whether community established penalty system for violations of use rules and regulations, and whether violations of use rules and regulations occurred. Total number of households per village, involvement of external organisations, distance to nearest market town, if cattle rearing is second most important source of livelihood in village, total number of local organisations in village, heterogeneity in oxen ownership and total area of village were used as determinants of collective action for grazing land management. Analysis of descriptive information, and Tobit and Probit statistical models have been employed.

We find that collective action for grazing land management is widespread in the highlands of Tigray and reportedly contribute to sustainable use of the resource. Most collective action is locally initiated and is organised at the village level. We find evidence for an inverted U-shape relationship between population and collective action. Market access detracts from collective action as does wealth heterogeneity of community. Community experience with local organisations favours collective action. These results imply that collective action for grazing land management may be more beneficial and more effective in areas with intermediate population and higher social capital, that are far from market places. In communities with higher wealth heterogeneity and closer to markets, alternative resource management arrangements such as privatisation may be more effective.

1 Introduction

Communal grazing lands are important sources of livestock feed in developing countries (ILRI 1999). In the presence of sufficient demand for livestock or livestock products, unrestricted access to the grazing lands may result in overexploitation of the resource and the scarcity rent of the resource would remain unappropriated. Each individual user of the resource enjoys the full benefit of his/her use of the resource but bears only a fractional part of the cost. As a result, the traditional uncontrolled and free grazing system in many developing countries has caused severe degradation of the grazing lands.

Alternative solutions have been proposed to solve this problem including privatisation, imposition and enforcement of use rules by external forces such as the government or state ownership of the resource (Wade 1986). It is unlikely that natural resource problems can be solved by private or state property alone. The transaction cost of enforcing use rules, imposed on the community by an external force, is likely to be prohibitively high due to the high incentives of individual users to shirk or the community members to collude against the use rules. Privatisation is not always superior to community resource management. For example, McCarthy et al. (2001) argue that private property of communal rangelands will become optimal only when collective action is so poor that it becomes welfare improving to appropriate land individually.

In the presence of collective action, institutional and organisational development, and the development of infrastructure, population pressure is more likely to have a positive impact on natural resources than in the absence of these developments (Pender 1999). The success of public policies to improve natural resource management depends to a large extent on the presence and effectiveness of local level institutions and organisations (Rasmussen and Meinzen-Dick 1995).

Community natural resource management is increasingly recognised as a viable alternative to privatisation or state ownership of the resource. As a result, local level resource management institutions and organisations to enforce them are receiving greater attention (Rasmussen and Meinzen-Dick 1995; Baland and Platteau 1996).

However, devolving rights to local communities to manage resources, establish use rules and regulations and enforce the rules is only a necessary condition for successful community resource management. Sustainable resource management also requires that community rules and regulations be effectively observed (Turner et al 1994; Swallow and Bromley 1995). Hence, identification of the factors that favour or retard the development and effectiveness of local institutions and organisations becomes important.

Although livestock contribute to land degradation, such allegations are sometimes exaggerated or even unfounded (Ehui et al. 1998). The underlying causes of land degradation may be incomplete property right systems including tenure insecurity and perverse financial incentives rather than increasing livestock numbers per se. With appropriate livestock development policies and public interventions in technology transfer, livestock have the potential to contribute significantly to the development of sustainable and environment friendly mixed crop–livestock systems. For example, livestock have the potential to speed up the cycling of nutrients back to the soil.

Ethiopia has the largest livestock population in Africa and stands 10th in the world. The livestock subsector is an important and integral component of the agricultural sector supplying draft power for cultivation, food and income to households, and insurance against risk.

However, the contribution of the subsector to the country's economy remains far below its potential due to feed, disease and management problems. Communal grazing lands have been important sources of livestock forage in the country. Recently, however, many communal grazing lands have become severely degraded due to the free and uncontrolled grazing system.

The degradation of grazing lands is especially severe in the northern Ethiopian region of Tigray. Cognisant of this problem, the improvement of animal feed production has become one major component in the regional livestock development strategy (Fitsum et al. 1999). In addition to efforts to increase the number of feed trial and seed multiplication sites, communities have been empowered to develop and enforce use rules and regulations of communal grazing lands. However, there is paucity of evidence regarding the nature of local level institutions and organisations for grazing land management in Tigray, or their effectiveness. More generally, since community resource management is likely to be context specific, there is need for more research on this in developing countries. In this regard, Runge (1992, p. 34) posits, 'Much more attention in research needs to be given, however, to the rich variety of contemporary resource management strategies that result from alternative environmental conditions and constraints'.

This paper attempts to provide evidence on the determinants of collective action and its effectiveness in communal grazing land management in a low potential highland setting where mixed crop–livestock system predominates. The paper has two interrelated objectives. First, using analysis of descriptive information, it evaluates the nature of community grazing land management in Tigray. Second, it analyses, using multivariate econometric methods, the factors influencing collective action and its effectiveness in managing grazing lands. Results are based on a survey of 50 communities and 100 villages in the highlands of Tigray in 1998–99. In this paper, communal grazing lands[1] with use restrictions and regulations are referred to as 'restricted grazing lands'.

1. Highlands are defined as those areas which are 1500 meters above sea level.

2   Livestock feeding systems in the highlands of Tigray

The study area, Tigray, is the northern most region of Ethiopia located on the Sudano-Sahelian dry land zone. It covers an approximate area of 50 thousand square kilometre with an average population density of about 65 person/km2 and population growth rate of about 3%. Most of the area is arid or semi-arid with annual precipitation of 450–980 mm. Mostly the rain falls within the months of June, July and August, exhibiting high intensity and high temporal and spatial variability (Berhanu 1998). More than 85% of the regional population lives in the rural areas and depends on mixed crop–livestock subsistence agriculture.

According to the 1998 livestock census, the region has about 3.04 million cattle, 0.94 million sheep, 1.47 million goats, 0.41 million equines and 0.013 million camels (BoANRD 1999). Livestock play an important role in the rural economy of Tigray. They are sources of draft power for traction and transportation, cash income from sale of livestock and livestock products, food such as milk for household consumption and manure to maintain soil fertility. The primary purpose of cattle production in the crop–livestock mixed farming systems of the region is draft power.

The contribution of the livestock subsector to the regional economy has been constrained primarily by lack of adequate and quality feed and existing livestock diseases. For instance, annual financial loss due to inadequate feed and management problems was once estimated to reach as high as 46.9 million Ethiopian birr (EB)[2] for beef production and EB 230.9 million for milk production (Desta 1997).

> 2. In 1998, US$ 1 = EB 7.

The major sources of livestock feed in the region include crop residues (45%), grazing lands (35%), browse (10%) and crop aftermath (8%) derived from 3.6 million hectare of cultivated land and 3.2 million hectare of grazing land (BoANRD 1997; UNECA 1997). Crop residues consist of straw, stalk, stovers, sheath and chaff. About 68% of the crop residue is fed to oxen; 20% to milking cows and newly castrated bulls while the remaining balance is fed to other livestock during critical periods (UNECA 1997). Prickly pear is also increasingly being used as animal feed, mainly in the Southern and Eastern zones of the region. The spineless cactus is chopped and given to animals while the spiny cactus is treated for spine removal with fire and knives. Considering the total number of livestock and the contributions of different sources of feed, the grazing lands in Tigray are supporting livestock far beyond their carrying capacity (Gebrekidan 1994; BoANRD 1997; UNECA 1997).

The livestock feed sources in the highlands of Tigray show slight difference by season (Tsigeweyni 1997). Livestock feed mostly on weeds and green grass from farm strips and bunds from July to September. From October to December, the dominant feed sources are crop aftermath and range lands. From January to June, crop residues, hay and cactus in some places are the primary sources of feed. In this altitude zone, critical feed shortage is observed in the period from July to September, while moderate feed shortage is observed during April to June. The period from October to March is the period where there is relatively adequate feed.

The grazing system in the region also varies by season. During the rainy season (July to September) when crops cover most arable lands, livestock are confined to grazing on valley bottoms, farm strips and steep hillsides (Tsigeweyni 1997). The grazing animals cause significant soil disturbance by trampling on the hillsides during the wet season, thus contributing to soil erosion. During the dry season, arable lands become grazing areas.

Free and uncontrolled grazing is the dominant grazing system in the region. In most parts of the region, grazing lands are common property resources.[3] Most of the grazing lands are grazed and trampled the whole year round without any resting period, resulting in depletion of palatable species and invasion by less palatable or unpalatable ones. Moreover, grazing on crop land contributes to soil compaction and the need for frequent tillage to prepare fields for crops, making practices such as reduced tillage less feasible.

> 3. Common property resources are defined as those resources which are collectively owned and managed by a given community. They are to be contrasted with open access resources that have no defined owner.

In addition to its contribution to the degradation of grazing lands, the grazing system has negative effects on the conservation efforts underway in the region. Physical conservation structures such as stone terraces and soil bunds are damaged by freely roaming livestock. Biological conservation practices such as grass strips and tree plantations are also being destroyed or trampled, reducing the chance for establishment and regeneration.

The free grazing system results in externality costs and benefits to those who do not own livestock. Fallow lands and cultivated lands after harvest are considered as grazing lands without access restrictions. Free grazing reduces vegetative cover thus contributing to soil erosion, reduction of soil fertility, decrease in soil organic matter and deterioration of the soil structure.

The farmers who own the land but who own no livestock are forced to bear the cost of maintaining the fertility of the land (for example, by applying commercial fertiliser or manure) or face the consequence of declining yields. However, landowners may also benefit from increased soil fertility due to manure left by grazing animals. Whether the externality costs outweigh the benefits remains an empirical question.

Most rural communities in Tigray reserve some grazing areas for dry season feed. In the Southern Zone, reserved grazing areas are mostly grazed by oxen from February until the onset of the next rainy season (July), while in the Central Zone, reserved grazing areas are used for hay making or are grazed by the whole livestock herd starting from October. However, the reserved grazing areas appear to be mainly the valley bottoms, thus contributing to the continuous degradation of the hillsides during the rainy season.

In the Eastern Zone, private ownership of grazing lands is practised, in addition to using reserved grazing areas for hay making. In some *woredas* (districts) of the zone such as Eurob and Hauzen, privately held grazing areas are converted to communal grazing lands after about two months of private grazing, while in Saesi Tsaeda Emba, private grazing is practised all year round (Tsigeweyni 1997). In some areas of Saesi Tsaeda Emba, farmers separate reserved grazing lands intended for cows and oxen. While valley bottoms are reserved for oxen, marginal grazing lands are reserved for cows.

Stall feeding of livestock is not practised in rural Tigray. The shift towards stall feeding needs to be seen within the overall context of agricultural production in the region (Berhanu 1998). On the one hand, stall feeding can increase availability of manure and reduce energy loss of livestock due to walking in search of feed where there is usually little. On the other hand, stall feeding requires more labour for watering, housing and breeding. Oxen and pack animals also need the physical exercise required for ploughing and transporting. Stall feeding may, however, be more feasible in more intensive dairy production activities close to cities.

3   Conceptual framework

The conceptual framework for this study is based on the theory of collective action (Wade 1988; Ostrom 1990; Baland and Platteau 1996), institutional analysis (North 1990), and transaction cost economics (Williamson 1986). Common property resources can be defined as having two basic characteristics, viz. exclusion is difficult albeit possible, and yield is subtractable (Vanderlinden 1999). Community members involved in the joint exploitation of a common property resource, therefore, face a dilemma of whether to compete for as big a share from the resource pie as possible or co-operate to increase the resource pie through collective action to manage the resource (Vanderlinden 1999).

Analysis of individual incentives to contribute to collective action for common property resource management has been the most dominant economic approach to the study of the determinants and effectiveness of collective action (Baland and Platteau 1999). Underlying these incentives is the perceived distribution of benefits and costs, which may in turn be influenced by factors related to the nature of the resource, the characteristics of the community, the interrelationships between the community and the resource and external environment such as the role of external organisations, and programmes and access to markets (Agrawal 2001).

Both institutional analysis (North 1990) and transactions cost economics (Williamson 1986) hold that individuals weigh costs and benefits of their decisions in specific action situations. Perceived obstacles and inducements in a given environment condition individual choices (Oakerson 1992). Hence, in this study factors related to the number and characteristics of participants involved (by facilitating or hindering trust and co-operation), types of choices available (by raising or decreasing opportunity cost of co-operation), external environment (through the effect on costs and benefits of the involvement of external organisations or programmes), importance of the resource for livelihood and past experience of the community in establishing and running local organisations are considered important in determining collective action for grazing land management.

4   Research methods and hypotheses

4.1 Research methods

The results are based on data collected from a survey of 50 *tabias* (the lowest administrative unit in Tigray consisting usually of four to five villages) in the highlands of Tigray in the 1998–99 cropping year. Sample *tabias* were selected using a stratified random sampling. *Tabias* were stratified based on distance from the nearest market town and presence of an irrigation project. Two villages were selected randomly from each *tabia*. A semi-structured questionnaire was administered in a group interview with community representatives at both the *tabia* and village levels. Each interview involved ten respondents chosen to represent different age groups, villages, primary occupations and gender. The survey collected information about changes in agricultural and natural resource conditions between 1991 and 1998 and their causes and effects.

Descriptive analysis of survey data was used to identify the nature and impact of community management on grazing lands, the role of local and external organisations in managing them, the institutions that evolved and their enforcement mechanisms. Econometric analysis was used to examine the determinants of collective action and its effectiveness in managing grazing lands.

Effective collective action for resource management requires that the beneficiaries prepare and agree on a set of rules of restrained access to the resource; make arrangements for financial, labour or other contributions required for the management of the resource and lay out a system of enforcement of the use restrictions and community contributions. Thus, the indicators of collective action and its effectiveness used in the econometric analysis include: (1) area of restricted grazing land per household, (2) whether communities pay for guard to protect the grazing land, (3) the monetary value of contribution per household for grazing land management, (4) whether communities established penalty systems for violations of use restrictions, and (5) whether violations of use rules and regulations occurred in 1998. Communal grazing lands are used in every village, and the total area of the communal grazing land under use restrictions (restricted grazing area) is considered as an indicator of collective action. Community members may respond to non-co-operation by co-operating to increase each other's incentive to co-operate, through exhortation and penalties. Thus, establishment of penalty system is used as an indicator of collective action. Violations of use restrictions and regulations is used as an indicator of failure of collective action.

The type of regression model to use depends on the nature of the dependent variable. We use binary Probit models to examine the determinants of whether communities pay for guard, whether penalties were established and whether any violations occurred in 1998. We use a Tobit model for area of restricted grazing land per household and contributions per household for grazing land management since the data are censored. We corrected sampling stratification and weights using the survey data estimation version for Probit models (SVYPROBT) and the Tobit model (SVYINTRG) using STATA software.

4.2 Hypotheses

The factors used to explain differences in collective action include the number of total households in a village, wealth heterogeneity of the community, experience with local organisations, distance to market, involvement of external organisations or programmes, whether cattle production is the second most important source of livelihood in a community and the total area of the community.

When the number of households is small, collective action may be low due to fixed costs, while when the number of households is very high, collective action may also be low due to increasing variable transaction costs of attaining and enforcing collective action or higher competition for the resource (Pender and Scherr 1999; Berhanu et al. 2001; Otsuka and Place 2001). Hence we hypothesise an inverted U-shape relationship between number of households in a village and collective action for grazing land management with intermediate levels of population density favouring collective action, while low and very high population densities hindering collective action.

The effect of heterogeneity on collective action is unresolved since communities may be heterogeneous in several aspects including socio-cultural background, interests and endowments and each of these aspects may affect collective action differently (Baland and Platteau 1996; Baland and Platteau 1999). The conditions under which certain aspects of heterogeneity enhance or undermine collective action also remains unknown (Varughese and Ostrom 2001). In this study, we considered heterogeneity in terms of oxen ownership in the community. We hypothesise that heterogeneity in oxen ownership may undermine collective action for grazing land management because of possible divergence of interests in and perceived benefits from use of the grazing lands. Since land in the study area is equitably distributed based on family size, oxen ownership remains an important differentiation factor of social classes. We measured heterogeneity by the coefficient of variation of the distribution of the proportion of households with no ox, one ox, two oxen and more than two oxen.

On the one hand, external organisations can favour collective action by providing technical support and inputs, provided that these interventions are complementary to local collective action and demand driven. On the other hand, external organisations may retard collective action if their role substitutes local collective action (such as by replacing local effort or dictating management decisions) or otherwise undermining collective action (such as by increasing 'exit options' of local community members) (Pender and Scherr 1999; Berhanu et al. 2001). We investigated the effect of external organisations by including a dummy variable for whether the restricted grazing area was promoted by an external organisation. Since almost all restricted grazing areas are managed at the village level, we are not able to test for the effect of the level of management (i.e. village vs. *tabia*) on collective action.

Experience with local organisations should favour collective action due to possible learning effects and the effect of social capital on the costs or ability to enforce collective action (Rasmussen and Meinzen-Dick 1995; Baland and Platteau 1996; Pender and Scherr 1999). Up to ten different local organisations operate in the study area. Not all communities have all the local organisations. We measured differences in community experience with local organisations by the number of local organisations operating in a given community.

Communities who depend on a common property resource and are likely to use the resource over a long time horizon, may be more likely to self-organise to manage the resource collectively (Varughese and Ostrom 2001). The primary source of livelihood for rural communities in the study area is cereal crop production. Communities showed difference in their second most important source of livelihood. We include a dummy variable of whether the second most important livelihood source in a given community is cattle rearing. We expected that where cattle rearing is an important livelihood strategy, collective action for grazing land

management will be high.

The effect of market access on collective action is mixed. While better market access may increase the value of the resource and the return from managing the resource effectively, thus favouring collective action, better market access may also decrease the incentive of members to abide by community rules by increasing the opportunity cost of labour or by providing more 'exit' options, making enforcement of rules more difficult (Baland and Platteau 1996; Pender and Scherr 1999; Berhanu et al. 2001). We measured market access by the walking time taken to reach the nearest market town from the village.

5   Results

5.1 Descriptive analysis

Grazing areas with some regulations of use (restricted grazing areas) are common in rural communities in the highlands of Tigray. All villages in the highlands have some type of grazing land (including both unrestricted and restricted grazing areas) and almost 90% of the villages have one or more restricted grazing areas. The average total restricted grazing land area per village is 38 ha and the average area of a particular grazing land is 10.5 ha (Table 1). On average, each village in the highlands has about four restricted grazing areas. However, there is a wide variation in the number and area of restricted grazing lands per village.

Table 1. *Characteristics and allowed uses of restricted grazing areas (standard errors in parentheses).**

Item	Village level	Grazing area level
Percentage of villages with restricted grazing lands	89 (0.0096)	
Number of restricted grazing lands per village	3.98 (0.16)	
Average area of restricted grazing lands (ha)	38.2 (3.615)	10.45 (1.112)
Average age of restricted grazing land (years)		23 (0.814)
Percentage of grazing lands promoted by external organisations		32 (0.0349)
Value of community contribution for grazing land management (EB)		
Value per grazing land		1580 (615.28)
Value per hectare		300 (60.48)
Value per household		3.66 (0.852)
Allowed uses of restricted grazing lands (percent)		
Cutting grass		22 (0.03)
Fuel wood collection		53 (0.034)
Collecting dung		90 (0.021)
Collecting fruits		66 (0.033)
Beekeeping		60 (0.032)
Cutting trees		0 (0.0)
* = Means and standard errors are corrected for sampling stratification and weights.		

Almost all restricted grazing areas are used exclusively by the village that manages them. More than half of the restricted grazing areas are used for grazing only by oxen while the remaining are grazed by all animals. There is a variation in the period during which grazing lands are used for grazing. In 42% of the cases the grazing lands are used only from September to December, 29% from January to May, and 13% from June to August. Only oxen are allowed to graze in the rainy season from June to August. In a few cases, grazing is allowed after the grass is cut.

In addition to grazing livestock, other allowed uses of the restricted grazing areas include cutting grass for feed or construction, fuel wood collection from dead trees, dung collection and bee keeping. However, cutting trees or shrubs is not allowed. All communities reported that the grazing lands have regenerated significantly due to the restricted uses.

There appears to be a long tradition of developing and enforcing use regulations of grazing areas in Tigray. More than 58% of the restricted grazing areas in the surveyed villages were established prior to 1966, while only about 17% have been established since 1991. On average, a restricted grazing area in

the highlands was established 23 years ago. The village administration is the local organisation principally mandated for the management of the grazing areas. In a few cases, a group of elders has the management responsibility. In addition to the village organisations, the regional Bureau of Agriculture is also involved in management of the grazing areas. The village administration is mostly involved in organising potential beneficiaries, drafting of use rules and regulations and enforcement of the rules once they are ratified by beneficiaries. In a few cases, the village administration finances guards. The Bureau of Agriculture is mainly involved in the provision of material and technical assistance, with limited role in organising beneficiaries. The Bureau is not involved in the preparation of use rules and regulations.

The most frequent contribution of village members in management of the grazing lands is cash or in kind contribution for guard payment. Other contributions of village residents include uncompensated labour contribution for the construction of soil and water conservation practices, guarding the area on rotation basis and fencing and weeding. The average value of total community contributions for management of a grazing land in 1998 was EB 1580 (US$ 226) per grazing land, with per hectare average value of EB 300 (US$ 43). The average contribution per household was EB 3.66.

Most grazing areas in the highlands (68%) were not promoted by an external organisation or programme, indicating the prevalence of local initiative for collective action in managing grazing lands. In cases where the grazing areas were promoted by an organisation or a programme, the Bureau of Agriculture took the lead.

The most common way of protecting the grazing lands is by hiring guards (77% of restricted grazing areas) paid by contributions from households in cash or in kind or in return for benefits from using the grazing areas. The dominant way of compensating guards is payment in cash or in kind. In a few cases guards are paid from food-for-work programmes. When cash payment is used, a guard is paid EB 40/month (US$ 6.00) on average. In some villages only those who own oxen contribute for guard payment. When a guard is not hired, village households rotate the responsibility for guarding the grazing lands (21.5% of restricted grazing areas) or fence the grazing land (0.8% of restricted grazing areas). Mutual trust among villagers is used in 0.4% of the cases.

Penalties for violations of use restrictions of grazing lands are widely applied in the highlands of Tigray. In 1998, violations of use restrictions were reported in 26% of the restricted grazing lands. In about 81% of the cases, violations were penalised when they occurred. Farmers do not perceive any problems as a result of the use restrictions of the grazing areas in terms of shortage of grass, harbouring pests, fire hazard, shortage of fuel wood or uncertainty about receiving benefit from them. All restricted areas remained restricted once they were established.

The most frequent violations of use restrictions of the grazing lands reported in 1998 were letting animals graze while grazing was not allowed and cutting grass for feed and construction without permission. Other violations include cutting roots, branches, leaves or trees and collecting fuel wood. Communities mostly apply penalty in cash.

The survey asked about penalties used by communities for violations of use restrictions when the area was first established in 1998. Among violations that were penalised by cash fine, 61% during establishment and 72% in 1998 were applied to violations of grazing animals and cutting grass and trees. In some cases (21% of penalties during establishment and 18% in 1998) the village courts were mandated to decide on penalties for violations. Confiscation of the cut grass and trees and implements were used in few cases.

Compared to during establishment the frequency of cash penalties and imprisonment increased by 1998. While mandating the village court to decide on penalties, penalty in kind and confiscation decreased in 1998. In a few cases penalties were not initially developed when the use restrictions were first established. The most frequently cited benefit received from the grazing lands in 1998 is grazing animals while feed is in short supply. On average, 42% of households in each village received benefit from grazing animals in 1998. Other benefits to rural households include cutting grass for feed and other purposes, collecting dung and collecting fuel wood from dead trees.

Some indicators of collective action showed significant differences by market access[4] (Table 2). Villages with relatively lower market access reported significantly higher violations of use rules and regulations but made significantly higher contributions per household for grazing land management. There was no significant difference in the other indicators of collective action based on market access.

4. Communities were classified into high market access if the distance to the nearest market place is less than or equal to 10 km, while if the distance is more than 10 km were classified into low market access.

Table 2. *Indicators of collective action for grazing land management by market access* [†] [‡] *(standard error).*

Indicator	Low market access	High market access
Percentage of villages with restricted grazing area	75.62a (0.059)	63.65a (0.089)
Average restricted area per household (ha)	0.349a (0.064)	0.403a (0.157)
If community paid for guard (percent of restricted grazing areas)	74.49a (0.05)	67.21a (0.069)
If community established penalty system (percent of restricted grazing areas)	98.21a (0.009)	95.30a (0.023)
If violations of use restrictions occurred (percent of restricted grazing areas)	43.10a (0.044)	5.20b (0.021)
Average per household contributions for restricted grazing land management (EB)	4.239a (1.081)	1.573b (0.414)
Average per hectare value of community contribution for restricted grazing land management in 1998 (EB)	192.30a (53.23)	326.31a (74.89)
[†] = Figures (in the same row) followed by different letters are significantly different from each other at least at 5% level. [‡] = Means were corrected for sampling stratification and weights and standard errors are robust to hetroskedasticity and non-independence within the primary sampling units (*tabias*).		

When communities are classified into high and low population densities,[5] most of the indicators of collective action were significantly different (Table 3). Average area of restricted grazing land per household, percentage of villages which established penalty system, percentage of violations of use rules and regulation in 1998, and average household contribution for grazing land management were higher at low population density, while the percentage of communities paying for guard was higher at higher population density.

5. Communities were classified as low population density areas if population density is less than or equal to 100/km2 and high population density if higher than 100/km^2.

Table 3. *Indicators of collective action for grazing land management by population density in community* [†][‡] *(standard error).*

Indicator	Low population density	High population density
Percentage of villages with restricted grazing area	80.08a (0.083)	73.32a (0.0612)
Average restricted area per household	0.133a (0.041)	0.040b (0.01)
If community paid for guard (percent of restricted grazing land)	60.58a (0.087)	78.26b (0.043)
If community established penalty system (percent of restricted grazing area)	99.27a (0.007)	96.77b (0.012)
If violations of use restrictions occurred (percent of restricted grazing land)	40.24a (0.067)	32.78b (0.042)
Average per household contribution for restricted grazing land management (EB)	7.694a (2.331)	1.569b (0.306)
Average per hectare value of community contribution for restricted grazing land management in 1998 (EB)	281.80a (86.1)	305.28a (78.91)
[†] = Figures (in the same row) followed by different letters are significantly different from each other at least at the 5% level. [‡] = Means were corrected for sampling stratification and weights and standard errors are robust to hetroskedasticity and non-independence within the primary sampling units (*tabias*).		

Some indicators of collective action also showed marked difference across zones,[6] perhaps due to differences in agro-climatic potential and other zonal specific factors (Table 4). The Southern Zone has the highest percentage of villages with restricted grazing lands, and the largest area of restricted grazing land per household while the Western and Central zones have the smallest areas of restricted grazing land per household. Villages in the Western Zone are most likely to pay for guard, followed by the Central and Eastern zones. The Eastern Zone had the fewest percentage of violations of use restrictions and regulations in 1998 and the lowest value of per household and per hectare contributions for grazing land

management. The econometric analysis shows whether the differences in collective action by market access, population and zones are significant after controlling for other variables.

6. The Tigray region is divided into four rural zones (Southern, Central, Eastern and Western). The Southern and Western zones are relatively high potential zones and the Western Zone has relatively higher availability of communal grazing lands.

Table 4. *Indicators of collective action for grazing land management by zone† ‡ (standard error).*

Indicator	Southern Zone	Central Zone	Eastern Zone	Western Zone
Percentage of villages with restricted grazing area	93.75a (0.051)	60.72b (0.968)	75.23ab (0.103)	54.02bc (0.151)
Average restricted area per household (ha)	0.162a (0.045a)	0.023bc (0.008)	0.042c (0.011)	0.009d (0.003)
If community pays for guard (percent of restricted grazing land)	50.49a (0.076)	85.02bc (0.054)	82.80c (0.053)	100d (0.0)
If community established penalty system (percent of restricted grazing area)	97.18a (0.016)	99.28a (0.007)	97.59a (0.013)	94.19a (0.058)
If violations of use restrictions occurred (percent of restricted grazing land)	53.22a (0.057)	32.61b (0.081)	7.54c (0.037)	58.04ab (0.178)
Average per household contribution for grazing land management (EB)	4.637a (1.418)	4.104a (1.567)	0.544b (0.159)	11.74ab (8.977)
Average per hectare value of community contribution for restricted grazing land management in 1998 (EB)	217.44a (45.74)	657.83b (223.63)	100.02c (32.15)	707.52abc (506.49)

† = Figures (in the same row) followed by different letters are significantly different from each other at least at the 10% level.
‡ = Means were corrected for sampling stratification and weights and standard errors are robust to hetroskedasticity and non-independence within the primary sampling units (*tabias*).

To summarise the descriptive analysis, we find that restricted grazing areas are widespread in the highlands of Tigray and are managed only at the village level. Most grazing areas are established through local initiative and village administrations are principally involved in its management. Village members contribute in cash or in kind for guard payment and contribute uncompensated labour for management. When a guard is not used for protection, village members take turns to protect the land or they use fences. The regional Bureau of Agriculture is involved mainly in the provision of technical and material assistance. Since oxen supply draft power for traction, a critical input for crop production, the restricted lands are mainly used for grazing oxen. Communities use cash penalties for violations. The level and effectiveness of collective action for grazing land management appears to differ by population density and market access, as well as across zones. In the next section, we present results of econometric analysis on the determinants of collective action and its effectiveness.

5.2 Econometric analysis

The results of econometric analysis are presented in Table 3. We included dummy variables 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 higher rainfall), as well as other zone specific differences. We included population density and population density squared to test for an inverted U-shape relationship between population density and collective action.

We find that the Western Zone has the least area of restricted grazing lands per household, consistent with the existence of a relatively more abundant grazing land in the zone compared to other zones of the region, thus perhaps reducing the need for restricted grazing areas. The Central and Eastern zones also have less areas of restricted grazing lands per household compared with the Southern Zone. We also find that communities in the Central Zone are more likely to pay for guard and are more likely to establish penalty systems for violations of use restrictions and regulations than in the Southern Zone. Communities in the Eastern Zone are less likely to violate use rules and restrictions and more likely to establish penalty systems than in the Southern Zone.

Communities are more likely to pay for guard at intermediate population than at low or very high total population. The turning point in this relationship (where maximum probability of communities paying for guard occurs) is 450 households per village. This is well within the range of total number of households per village and very well close to the average number of households per village (total number of households per village in the study area ranged from 85 to 1050 with an average value of 410). We also find violations of use restrictions are least likely to occur at intermediate population (368 households per

village). These results of the effect of population on collective action for grazing land management are consistent with the hypothesis of an inverted U-shape relationship between population and collective action. Collective action is probably low at low population due to the effect of fixed costs associated with collective action and at very high population due to the increasing marginal costs of collective action as population increases.

The involvement of external organisations in promoting restricted grazing areas reduced the likelihood of communities paying for guard, suggesting that the need for communities to pay is eliminated by payment made by the external organisations. Involvement of external organisations has a positive (but statistically insignificant) effect on household contributions for grazing land management.

Communities with greater presence of local organisations make higher contributions per household for grazing land management and are more likely to establish a penalty system and are less likely to have violations of use restrictions and regulations. These results are consistent with the hypothesised effect of experience with local organisations on collective action for resource management. However, we also find a negative effect of experience with local organisations on the likelihood of communities paying for a guard; similar to the effect of involvement of external organisations. Perhaps a guard is less necessary in communities with greater investment in such local social capital.

Communities that are more distant from the nearest market town are more likely to pay for guard and to establish a penalty system for grazing land management, suggesting that the more distant communities are the higher their need for restricted grazing lands and the more likely that collective action may be used because of lower opportunity cost of labour or limited exit options in such areas. These results suggest that in areas closer to markets, private management of grazing lands may be a better option.

Whether or not cattle rearing is a second most important source of livelihood in a community it failed to affect any of the indicators of collective action significantly. This may be because of the fact that cereal crop production is the first most important source of livelihood in all communities and cattle rearing is considered as supplementary to crop production.

Heterogeneity in oxen ownership tends to detract from collective action for grazing land management. Heterogeneity increases the likelihood of violations of use restrictions and regulations (an indicator of failure of collective action). Heterogeneity explained household contribution for grazing land management negatively but was statistically insignificant. We also find that total area of community has a positive effect on area of restricted grazing land per household.

A possible explanation for the weak influence of some of the explanatory variables is that there may be multicollinearity among the explanatory variables. We tested for problems of multicollinearity and found that potential problems only between the total number of households in village and its squared value. We have retained both variables as they were necessary to test the hypothesised inverted U-shaped relationship. The variance inflation factors of all other variables were below 3.

Table 5. *Determinants of collective action for grazing land management (t-statistics in parentheses).[a]*

Explanatory variable	Area of restricted grazing land per household	Whether community pays for guard[b]	Average value of household contribution for grazing land management	If community established penalty system	If violations of use restrictions and regulations occurred in 1998
Central Zone (cf. Southern Zone)	0.169 (3.09)	1.017 (2.775)	2.126 (0.61)	1.002 (1.773)	0.254 (0.773)
Eastern Zone (cf. Southern Zone)	0.115 (2.24)	0.073 (0.193)	2.757 (0.71)	0.978 (1.774)	1.214 (2.972)
Western Zone (cf. Southern Zone)	0.259 (3.51)		2.000 (0.43)	0.053 (0.076)	0.153 (0.265)
Total number of households in village (average of 1991 and 1998)	0.00038 (0.76)	0.033 (3.482)	0.009 (0.17)	0.0046 (1.21)	0.00495 (1.715)
Total number of households in village squared	0.000000065 (0.14)	0.0000372 (3.524)	0.00001 (0.00004)	0.000006 (1.72)	0.0000067 (2.39)
If restricted grazing area was promoted by external organisation		1.888 (4.599)	3.380 (1.30)	0.249 (0.745)	0.076 (0.236)
Distance to nearest market town (walking time in minutes)	0.000034 (0.31)	0.0078 (3.90)	0.006 (0.44)	0.005 (2.407)	0.0016 (1.175)
If cattle rearing is second most	0.0237 (0.51)	0.255 (0.546)	0.585 (0.17)	0.031 (0.079)	0.231 (0.857)

important livelihood source					
Total number of local organisations operating in village	0.0037 (0.26)	5.375 (2.438)	1.906 (2.67)	1.591 (1.91)	1.502 (1.699)
Heterogeneity of oxen ownership in community	0.029 (0.278)	0.481 (0.18)	25.708 (1.49)	2.816 (1.27)	3.713 (1.934)
Total area of community	0.0015 (3.19)	0.0067 (1.436)	0.0639 (0.0332)	0.0068 (1.581)	0.0036 (1.128)
Intercept	0.218 (0.97)	3.873 (1.897)	9.845 (0.45)	0.3812 (0.334)	0.248 (0.258)
Type of regression	Tobit	Probit	Tobit	Probit	Probit
Number of positive observations/total obs	74/100	119/154	161/225	210/231	62/237

a. All regression results were corrected for sampling stratification and weights and standard errors are robust to hetroskedasticity and non-independence within the primary sampling units (*tabias*).
b. Western Zone was dropped since Western Zone = 0 predicted success (community paying for guard) perfectly.

6   Conclusions and implications

Rural communities in Tigray have long tradition of developing and enforcing use regulations of grazing areas. According to survey respondents, use regulations reportedly contribute to significant regeneration of grazing lands, supporting the role of community resource management in redressing resource degradation. Restricted use of grazing lands are maintained once established. Village organisations are primarily responsible for the management of restricted grazing areas by organising and informing beneficiaries and establishing and enforcing use regulations; with technical and material assistance from the regional Bureau of Agriculture. Beneficiaries contribute to grazing land management through cash and in kind for protection and uncompensated labour contribution for the development of the grazing lands. Given the crucial role of traction for crop production, oxen are the priority users of the restricted grazing lands.

Communities which have smaller areas of restricted grazing lands per household exhibited higher levels of various indicators of collective action for grazing land management, such as communities paying for guard, establishment of penalty systems and reported less violations. These results, combined with the finding that restricted grazing areas remain enforced once established, suggest that once the hurdle of establishment of restricted grazing areas is overcome, collective action is likely to be effective.

We found evidence for an inverted U-shape relationship between population level and collective action for grazing land management. Collective action is highest at intermediate population level. When population is low the fixed costs of collective action per head is high, thus undermining co-operation. At high population level, the increasing variable costs of collective action detract co-operative efforts.

Experience in organising and running local organisations encourages collective actions for grazing land management, perhaps due to the learning effect of managing co-operative effort or because social capital helps to reduce the cost of attaining and enforcing collective action. Market access may detract from collective action by increasing the opportunity cost of labour or by providing more exit options to rural communities. Heterogeneity in oxen ownership appears to detract from collective action for grazing land management.

The findings imply that community grazing land management can contribute to a more sustainable use of grazing lands and the alleviation of feed shortage problems. Collective action for grazing land management may be more beneficial and more effective in areas with intermediate population and areas that are far from market places. In communities with higher wealth heterogeneity and are closer to markets, alternative resource management arrangements such as privatisation may be more effective.

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Annex: Summary statistics of variables used in regressions*

Variable	No. of observations	Mean	Standard error	Minimum	Maximum
Whether village has restricted grazing area	100	0.89	0.05	0	1
Area of restricted grazing per household (ha)	100	0.067	0.015	0	1.916
Whether community pays for guard	154	0.72	0.042	0	1
Average household contribution for grazing land management (EB)	226	3.661	0.852	0	63.157
Whether village established penalties	231	0.97	0.008	0	1
Whether violations occurred	229	0.35	0.036	0	1
Eastern Zone	231	0.23	0.047	0	1
Southern Zone	231	0.3	0.05	0	1
Western Zone	231	0.13	0.038	0	1
Central Zone	231	0.32	0.053	0	1
Households per village	100	410	20.62	85	1050
Walking distance from village to nearest *woreda* town (minutes)	231	200	8.04	10	720
If grazing land promoted by external organisation	231	0.31	0.035	0	1
If cattle rearing is second most important livelihood source	231	0.68	0.053	0	1
Number of local organisations operating in village	231	4.1	0.124	1	6
Heterogeneity of oxen ownership (coefficient of variation)	231	0.25	0.007	0.1	0.45
Area of community (km^2)	231	62.08	4.78	12.3	179
* = Means and standard errors are corrected for sampling weights and stratification.					