Policies for livestock development in the Ethiopian highlands

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Abstract

Since 1991, there have been significant changes in utilisation of feed resources in the Ethiopian highlands: while use of communal grazing lands and private pastures has declined, use of crop residues and purchased feed has increased. In addition, although use of animal health services, and adoption of improved livestock breeds and modern management practices have increased, ownership of various types of livestock has declined. Rapid population growth has contributed most to the declining trends in grazing resources and ownership of livestock, showing the negative effects of increasing pressure on already degraded resources in the Ethiopian highlands. Conversely, access to own land, increased participation in credit and extension programmes targeting livestock, and improvement in access to markets have had significant positive impacts on adoption of improved livestock technologies and ownership of livestock. Thus, reducing population growth, and improving access to markets and credit and extension programmes targeting livestock can enhance the role of livestock in improving food security and reducing poverty, especially in the mixed crop-livestock farming systems as exist in the East African highlands.

Keywords: Adoption; Ethiopian highlands; livestock technologies and ownership.

1 Introduction

In Ethiopia, livestock contribute about 30–35% of agricultural gross domestic product (GDP) and more than 85% of farm cash income. The livestock subsector also contributes about 13–16% of total GDP. Between 1987–88 and 1995–96, the share of livestock in total exports averaged 16%[1](Befekadu and Berhanu 2000). Although Ethiopia has the largest livestock population in Africa, performance in the production of the major food commodities of livestock origin has been poor compared with other African countries, including neighbouring Kenya (Befekadu and Berhanu 2000). Inadequate feed and nutrition, widespread diseases and poor health, poor breeding stock, and inadequate livestock policies with respect to credit, extension, marketing and infrastructure have been cited as major constraints affecting livestock performance (Befekadu and Berhanu 2000; Lakew et al. 2000).

1. The share of livestock in total exports, however, declined from 21% in 1997–88 to 12.9% in 1995–96, with hides and skins contributing about 93% of total livestock exports within this period (Befekadu and Berhanu 2000).

Livestock have diverse functions for the livelihood of farmers in mixed crop–livestock systems in the highlands of East Africa. Livestock provide food in the form of meat and milk, and non-food items such as draft power, manure and transport services as inputs into food crop production, and fuel for cooking. Livestock are also a source of cash income through sale of the above items, animals, hides and skins. Furthermore, they act as a store of wealth and determine social status within the community. Due to these important functions, livestock play an important role in improving food security and alleviating poverty. Because they are central to nutrient cycling, livestock are important to the efficiency, stability and sustainability of farming systems in the East African highlands (Ehui et al. 1998).

In 1991, when the present federal government came to power it launched, in addition to market liberalisation, the Agricultural Development Led Industrialisation (ADLI) strategy to improve the productivity of the agricultural sector, within the framework of transforming the entire economy such that the relative contributions of agriculture, industry and services to economic growth would shift significantly in favour of the latter two over time. With respect to the livestock subsector, the development strategy seeks to: 1) enhance the quality and quantity of feed by allocating sites for grazing, providing improved animal feed and improving extension services to farmers; 2) increase livestock health service coverage and improve vaccination sites; and 3) improve productivity of local cows by artificial insemination, but also to preserve and improve indigenous breeds. From a survey conducted in 1999–2000 in northern Ethiopia to examine the development of the livestock subsector since 1991 when ADLI was launched, we found that there have been significant changes in utilisation of feed resources: while use of communal grazing lands, private pastures, woodlots and forest areas as feed sources has declined, use of crop residues and purchased feed has increased. In addition, we found that although use of animal health services and adoption of improved livestock breeds and modern management practices (e.g. artificial insemination, stall feeding and fattening) have increased, ownership of various types of livestock has declined.

The objective of this paper is to determine the factors that have contributed to the above changes in the livestock subsector in the mixed crop–livestock farming systems in the Ethiopian highlands. Several factors including agricultural potential, changes in access to markets, population growth, land tenure policy, and changes in access to credit and extension programmes are hypothesised to affect the changes in livestock development. We found that improvement in access to markets, access to own land, and increased participation in credit and extension programmes targeting livestock have had significant positive impacts on ownership of livestock and adoption of improved live–stock technologies. Population pressure, on the other hand, has had negative impacts on ownership of livestock and grazing resources. Thus, reducing population growth and improving access to markets and credit and extension programmes targeting livestock can enhance the role of livestock in the mixed crop–livestock farming systems as exist in the Ethiopian highlands.

The rest of this paper is organised as follows. The next section describes the data and then examines trends since 1991 in ownership of various types of livestock, use of live–stock feed resources and animal health services, and adoption of improved breeds and modern management practices. Section 3 presents the empirical framework for analysing the factors contributing to the trends. Results and discussion are presented in Section 4, and conclusions and implications are drawn in Section 5.

2 Data

2.1 Survey

This research is based upon a community-level survey conducted in 98 villages in the Amhara region of northern Ethiopia in 1999–2000. A stratified random sample of 49 Peasant Associations (PAs)[2] was taken and two villages were selected randomly from each PA from highland areas (>1500 metres above sea level (masl)) of the region. Using *woreda* (district) level secondary data, the stratification was based upon indicators of agricultural potential (whether or not the *woreda* is drought-prone, as classified by the Ethiopian Disaster Prevention and Preparedness Committee), market access (access or no access to an all-weather road) and population density (1994 rural population density greater than or less than 100 persons/km^2). Two additional strata were defined for PAs that included an irrigation project (in drought-prone vs. higher rainfall areas), resulting in a total of 10 strata. Five PAs were then selected randomly from each stratum (except the irrigated drought-prone stratum, in which there were only four PAs), for a total of 49 PAs and 98 villages. *Woredas* predominantly (more than 50% of total area) below 1500 masl were excluded from the sample frame.

2. Peasant Associations are the lowest level local government in Ethiopia and usually consist of 3 to 5 villages.

3. Compared with other regions, Amhara is ranked first in number of goats, second in cattle, sheep, asses, horses and poultry, and fifth in camels (CSA 1998).

Information was collected at both PA and village level using group interviews with about ten respondents from each PA and village, selected to represent different genders, age groups, occupations and in the PA-level survey, different villages. Information collected included perceived changes in use of various feed resources, adoption of improved livestock technologies and management practices, and ownership of livestock since 1991 (the year when the current government replaced the former Marxist government). The data were supplemented by secondary information on population from the 1994 population census, geo-referenced maps of the boundaries of each sample PA and geographic attributes, including altitude and climate.

2.2 Trends since 1991 in the livestock subsector in Amhara region

The Amhara region is located in the north-western part of Ethiopia. The region covers about one-eighth of the total area of the country and is home to about 27% of the total human population (Befekadu and Berhanu 2000) and 35% of the total livestock population[3] (BoA 1999). In the region, livestock and human populations are concentrated in the highland areas, which constitute about 66% of the total area (Befekadu and Berhanu 2000). Historically, human and livestock settlements have concentrated in the highland areas, especially in the 2300–3200 masl range (*dega* agro-ecological zone), because of the relatively good rainfall reliability, cool temperatures and the absence of diseases (e.g. malaria and trypanosomosis).

From the survey conducted in the region, we found that in general, ownership of livestock has declined between 1991 and 1999, with the percentage decrease being larger in drought-prone areas compared with higher rainfall areas (Table 1). The only exception to the declining trend is ownership of donkeys, which increased slightly, particularly in higher rainfall areas. Community respondents revealed that a combination of loss to drought and diseases, and sale during crop failure were the major causes for the declining ownership of livestock. Recurrent drought (late rains or failure of main and small rains) is a common phenomenon in Ethiopia, especially in the central and north-eastern highlands, stretching from northern Shewa through Wello into Tigray, and low-lying areas in the southern and south-western parts, leading to severe food shortage and loss of livestock (Webb et al. 1992). For example, during the 1971–75 drought period, resulting from a sequence of rain failures, it was estimated that 50% of livestock was lost in the Wello and Tigray areas (Befekadu and Berhanu 2000).

Table 1. *Proportion of households owning livestock, by agricultural potential.*

		Sample mean		Percentage change
		1991	1999	
Oxen	All communities	0.73	0.59	–19
	Drought-prone areas	0.71	0.41	–42
	Higher rainfall areas	0.75	0.73	–3
Cows	All communities	0.46	0.30	–35
	Drought-prone areas	0.50	0.28	–44
	Higher rainfall areas	0.43	0.31	–28
Heifers	All communities	0.34	0.20	–41
	Drought-prone areas	0.35	0.16	–54
	Higher rainfall areas	0.33	0.22	–33
Bulls	All communities	0.33	0.18	–46
	Drought-prone areas	0.37	0.15	–60
	Higher rainfall areas	0.29	0.20	–31
Calves	All communities	0.35	0.20	–43
	Drought-prone areas	0.39	0.17	–56
	Higher rainfall areas	0.32	0.22	–31
Sheep	All communities	0.38	0.25	–34
	Drought-prone areas	0.47	0.21	–55
	Higher rainfall areas	0.31	0.28	–10
Goats	All communities	0.28	0.15	–46
	Drought-prone areas	0.36	0.13	–64
	Higher rainfall areas	0.22	0.16	–27
Donkeys	All communities	0.32	0.36	13
	Drought-prone areas	0.33	0.32	–3
	Higher rainfall areas	0.31	0.40	29
Horses	All communities	0.09	0.08	–11
	Drought-prone areas	0.10	0.05	–50
	Higher rainfall areas	0.09	0.10	11
Mules	All communities	0.08	0.05	–38
	Drought-prone areas	0.12	0.07	–42
	Higher rainfall areas	0.05	0.04	–20

Poultry	All communities	0.61	0.56	–8
	Drought-prone areas	0.80	0.70	–13
	Higher rainfall areas	0.48	0.47	–2
Note: Sample means are adjusted for stratification, weighting and clustering of sample.				

We found that with the exception of purchased feed[4] and crop residues, use of other sources of fodder (communal grazing lands, woodlots, forests, homestead (e.g. prickly pear) and private pastures) declined between 1991 and 1999, and the decline was larger in higher rainfall areas (Table 2). The increase in use of crop residues was greater in higher rainfall areas, while increase in use of purchased feed was greater in drought- prone areas, with the proportion of households buying feed being about three-times larger in drought-prone areas (Table 3). Consistent with the decline in use of communal grazing lands was the perception that both availability and quality have been declining.

4. Purchased feed includes oil-seed cakes, grain mill by-product, straw and *atella* (residue obtained from brewing local beer).

Table 2. *Perceived changes since 1991 in use of feed resources, and availability and quality of grazing lands, by agricultural potential.*

	Sample mean		
Feed sources	All communities	Drought-prone areas	Higher rainfall areas
Communal grazing lands	–0.41	–0.31	–0.49
Area enclosures	–0.02	–0.04	–0.00
Woodlots and forests	–0.11	–0.02	0.17
Private pastures	–0.28	–0.28	–0.29
Crop residues	0.60	0.29	0.83
Homestead (e.g. prickly pear)	–0.05	0.15	–0.19
Purchased feed	0.30	0.52	0.15
Availability of grazing land	–0.75	–0.78	–0.72
Quality of grazing land	–1.18	–1.15	–1.20
Notes: Change is an ordinal indicator of perception where: -2 = decreased significantly; -1 = decreased slightly; 0 = no change; +1 = increased slightly; and +2 = increased significantly. Sample means are adjusted for stratification, weighting and clustering of sample.			

Table 3. *Proportion of households buying feed and using animal health services, by agricultural potential.*

		Sample mean		Percentage change
		1991	1999	
Purchased feed	All communities	0.19	0.25	32
	Drought-prone areas	0.28	0.41	46
	Higher rainfall areas	0.12	0.13	8
Animal health services	All communities	0.33	0.55	67
	Drought-prone areas	0.23	0.49	113
	Higher rainfall areas	0.40	0.60	50
Note: Sample means are adjusted for stratification, weighting and clustering of sample.				

Community respondents revealed that use of grazing lands for cropping, settlement and other non-grazing activities have contributed to the decline in availability of grazing lands. Restrictions in use of communal resources (e.g. grazing lands, woodlots and forest areas) for fodder have also contributed to the declining use of these resources. We found that grazing lands managed at the village level, compared with those managed at the PA level, were more likely to have grazing restrictions (e.g. grazing at certain times of the year only and/or by certain animals only) imposed on them and for those restrictions to be enforced. With respect to the decline in use of private pastures as a source of fodder, about 45% of the communities stated that private pasture was being used for other purposes, due to shortage of cropland. With the other sources of feed on the decline, crop residues and purchased feed have tended to be used more.

Use of animal health services (vaccine and treatment), adoption of improved breeds (especially cattle and small ruminants) and modern management practices (AI, stall feeding and fattening) have increased since 1991 (Tables 3 and 4). The proportion of households using animal health services increased almost two-fold between 1991 and 1999. Although the proportion of households using health services was higher in higher rainfall areas, the proportionate increase between 1991 and 1999 in drought-prone areas was almost double that in higher rainfall areas. Common health problems, in order of importance, revealed by community respondents include anthrax, black leg, contagious bovine pleuro-pneumonia, pasteurellosis, parasites, rinderpest, trypanosomosis, sheep and goat pox, and African horse sickness. Adoption of improved breeds and adoption of stall-feeding practices since 1991, are more common than adoption of AI and fattening practices. Stall-feeding practice is twice as common in higher rainfall areas than in the drought-prone areas, whereas fattening practices are exclusively undertaken in higher rainfall areas.

Table 4. *Proportion of communities (with some of their residents) adopting improved breeds and modern livestock management practices since 1991, by agricultural potential.*

	All communities	Drought-prone areas	Higher rainfall areas
Improved breeds	0.26	0.28	0.25
Artificial insemination (AI)	0.05	0.04	0.06
Stall feeding	0.38	0.23	0.48
Fattening	0.03	0.00	0.05
Note: Sample proportions are adjusted for stratification, weighting and clustering of sample.			

Community respondents revealed that they adopted the above technologies in order to increase livestock productivity (e.g. meat and milk yield, and draft power). Improvement in access to animal health services and credit and extension were cited by most of the communities as having contributed to the above changes. Between 1995 and 2000 alone, 323 veterinary clinics were constructed (ANRSC 2000), while the number of vaccinations and treatments increased by 33% from 5.4 million in 1993–94 to 7.2 million in 1997–98 (BoPED 1998, 1999). In the past, credit and associated extension focused on crop production to the neglect of the livestock subsector. However, there are now many non-governmental organisations (NGOs) involved in the region providing credit for purchasing livestock, extension on improved forage development, and veterinary services.[5] In addition, compared with past programmes, the new extension system, Participatory Agricultural Demonstration Extension and Training System (PADETES), launched in the region in 1997, gives more attention to livestock by employing an integrated approach to crop, livestock, natural resource management and post-harvest technology.[6] Furthermore, a revolving credit programme to address especially livestock and other long-term investment activities has been instituted by the regional government. This credit fund is granted from various bilateral and multilateral organisations and administered by the Bureau of Agriculture (Hailu et al. 1998).

5. See Lakew et al. (2000) for details on NGO activities in the region.

6. PADETES was launched in Ethiopia in 1994.

As discussed earlier, livestock are very important to the livelihood of farmers engaged in mixed crop–livestock farming systems in the highlands. Therefore, a declining trend in ownership of livestock is cause for concern, especially in light of the livestock revolution that is anticipated to take place in developing countries within the next 20 years (Delgado et al. 1999) and the aim of making the livestock revolution work for the rural poor (ILRI 2000). Below we investigate the determinants of changes in use of feed resources, availability and quality of grazing lands, use of animal health services, adoption of improved breeds and modern management practices, and ownership of livestock.

3 Econometric approach

We have five types of dependent variables: changes in ownership of livestock; changes in use of feed resources; changes in availability and quality of grazing lands; changes in use of animal health services and purchased feed; and adoption of improved breeds and modern management practices. Depending on the type of dependent variable, different econometric techniques are utilised. However, the general econometric model to be estimated is given by the first difference model:[7]

$$\Delta y_v = a_2 - a_1 + b(x_{v2} - x_{v1}) + (c_2 - c_1)z_v + e_{v2} - e_{v1}$$

7. The first difference model eliminates unobservable fixed factors as a source of omitted variable bias.

where Dg_v represents the dependent variable in village v, x_{vt} is a vector of observed time-varying factors affecting Dg_v, *Zv* is a vector of observed fixed factors affecting Dg_v, and e_{vt} is a vector of unobservable factors affecting Dg_v The observed fixed factors, Z_v, will have an impact only if the marginal effect of such factors has changed over time. In the remaining part of this section, we first describe the dependent variables to be estimated and the specific econometric techniques utilised to estimate them. Then, the explanatory variables used in the estimations are presented.

3.1 Changes in ownership of livestock

We obtained information on the proportion of households that owned various types of livestock (cattle, small ruminants, pack animals and poultry) in a particular year. Here, we were interested in estimating the differences in the proportions between 1991 and 1999. We used ordinary least squares to estimate the differences in the proportions, since there was no censoring of the dependent variables (i.e. the proportions were never zero or one in any village).

3.2 Changes in use of feed resources, and availability and quality of grazing lands

Survey respondents provided their perceptions of change in use of various feed resources, and availability and quality of grazing lands. These perceptions were measured using ordinal indicators of change since 1991 with five possible levels: significant reduction, slight reduction, no change, slight increment and significant increment. Ordered Probit models (Maddala 1983) were therefore used to estimate the determinants of these changes.

3.3 Changes in use of animal health services and purchased feed

Similar to the information on ownership of livestock, we obtained information on the proportion of households that used animal health services and bought feed in 1991 and 1999. However, the resulting dependent variables that were calculated here were censored. For example, if the proportion of households buying feed was zero in 1991 and one in 1999, then the dependent variable was right censored. On the other hand, if the proportion of households buying feed was one in 1991 and zero in 1999, then the dependent variable was left censored. Therefore, we estimated a maximum likelihood censored regression model (or 'two-limit Tobit model'), taking into account both left and right censoring. The regression model on the change in proportion of households that bought feed was not statistically significant and so it is not reported.

3.4 Adoption of improved breeds and modern management practices

Survey respondents revealed whether or not some of the residents of the community had adopted improved breeds, AI, stall-feeding or fattening practices since 1991. We used Probit regression models to estimate the factors affecting the probability of adopting these technologies, where the dependent variable was one if some residents had adopted and zero otherwise. Since only 5 and 3% of the communities reported that some of their residents had adopted AI and fattening practices, respectively, there was not enough variation in the respective binary dependent variables to estimate the adoption of these management practices. Thus, these models were not reported.

3.5 Factors affecting changes

As noted earlier, we expected that changes in feed use, adoption of livestock technologies and change in ownership of livestock would be affected by several factors (both static and dynamic), including agricultural potential, changes in access to markets, population growth, land tenure policy, changes in participation in credit and extension programmes, education and community natural resource management (Pender et al. 1999; Lakew et al. 2000). These factors influence the awareness, availability, costs, benefits and risks associated with the different livestock technologies and management practices, and ownership of livestock.

Increase in population pressure can confound the production of forage thereby reducing the availability and quality of grazing resources. While better market access can increase the use of purchased feed, it can reduce the use of crop residues, as farmers may shift to producing more marketable crops (e.g. vegetables) whose residues may not be suitable for livestock feeding. Better market access may also increase use of animal health services and adoption of improved breeds, through increased availability of these technologies and/or use of cash income from sale of crops to subsidise their purchase. Credit and extension can contribute to livestock intensification by increasing ownership and adoption of improved breeds (through either in-kind livestock credit or cash credit to purchase livestock), use of crop residues (through increased use of fertiliser), adoption of stall feeding and use of health services (through extension services). Land redistribution, by improving farmers' access to land, can increase ownership of livestock. Conversely, by reducing field size for supporting livestock, land redistribution may reduce ownership.

Table 5 shows a description of the explanatory variables used in the analyses, their means and standard errors. Agricultural potential was measured by average annual rainfall (with a mean value of 1217 mm), altitude (2182 masl) and change in proportion of area irrigated (0.04%). Access to markets was measured by distance to the *woreda* town (37 km) and whether there had been an improvement in access to an all weather road (5%).[8] The other explanatory variables were: population growth, which was measured by change in number of households/km2 (11); changes in proportion of households that obtained credit and associated extension from the Amhara Credit and Savings Institution (ACSI; 9%),[9] Bureau of Agriculture (BoA; 20%) and other formal sources (e.g. NGOs 19%); change in adult literacy (15%); whether there had been land redistribution since 1991 (49%); whether villages managed their own grazing lands (39%); and change in the proportion of grazing lands suffering from severe erosion (6%). Note that the above changes, unless otherwise stated, refer to the difference between 1999 and 1991 levels.

8. We had wanted to use the change between 1991 and 1999 in walking time to the nearest all weather road. However, there were only two cases where the walking time had changed (decreased), although there were several cases where there was no 'access' in 1991 but there was access in 1999. Therefore, we used instead a dummy variable to represent an 'improvement in access to an all-weather road', where the variable = 1 referred to either a reduction in walking time between 1991 and 1999, or access in 1999 where access did not exist in 1991, and the variable = 0 otherwise.

9. ACSI started operating in the region in 1995 and so we used the proportion of households participating in 1999, which was equivalent to the change since 1991.

Table 5. *Means and standard errors of explanatory variables.*

Explanatory variable	Number of observations	Mean	Standard error
Annual rainfall (1000 mm)	98	1.2177	0.0312
Altitude (1000 masl)	98	2.1824	0.0809
Change in proportion of area irrigated	96	0.0004	0.0002
Distance (100 km) to *woreda* town	96	0.3739	0.0569
Whether there is improvement in access to all-weather road	98	0.0527	0.0267
Change in household density (100/km2)	88	0.1107	0.0169
Change in proportion of households with:			
- Credit from ACSI	98	0.0890	0.0300
- Credit from BoA	98	0.1988	0.0674
- Credit from other formal sources (e.g. NGOs)	98	0.1880	0.0715
Change in proportion of adult literates	98	0.1446	0.0159
Whether there was land redistribution since 1991	98	0.4879	0.0673
Whether village exclusively manages own grazing land	98	0.3909	0.0782
Change in proportion of grazing lands suffering from severe erosion	98	0.0583	0.0227
Notes: Change in explanatory variable refers to difference between 1991 and 1999 levels. Sample means and standard errors are adjusted for stratification, weighting and clustering of sample.			

One econometric problem to address here is that several of the time-varying explanatory variables may be endogenous. Population growth, change in participation in credit and associated extension programmes, change in area irrigated, change in adult literacy and change in proportion of grazing lands suffering from severe erosion may respond to or be affected by changing opportunities in agriculture and changing livestock technologies and ownership. We therefore tested for exogeneity of those potentially endogenous explanatory variables using a Hausman test (Hausman 1978; Greene 1993).[10] We failed to reject exogeneity of these explanatory variables in the regressions, except the regression for change in ownership of goats. Nevertheless, we report the robustness of the significant coefficients to using predicted values of these potentially endogenous variables.

10. The instrumental variables used to predict the potentially endogenous explanatory variables, in addition to the exogenous variables in the regressions, included the values of each of these endogenous variables in 1991, walking time to the nearest bus station in 1991 and change since 1991, walking time to the nearest grain mill in 1991 and change since 1991, walking time to the nearest primary school in 1991 and change since 1991, and the proportion of households that were landless in 1991. The instruments predicted most of the potentially endogenous variables fairly well: R^2 = 0.66 for change in household density; 0.64 for change in proportion of households obtaining credit from other formal sources; 0.59 for change in proportion of households obtaining credit from BoA; 0.33 for change in adult literacy; 0.28 for proportion of households obtaining credit from ACSI; and 0.25 for change in proportion of area irrigated.

4 Results

We present only results of those regressions in which the overall model was statistically significant at the 10% level of significance.

4.1 Changes in ownership of livestock

Table 6 shows the factors affecting changes in the proportion of households owning livestock. With respect to oxen, it is broken down further into ownership of one ox only, two oxen only and more than two oxen. Among the factors that were hypothesised to affect changes in ownership of livestock, rainfall, altitude, change in proportion of households obtaining credit from BoA and change in proportion of adult literacy had no significant impact on change in ownership of any type of livestock.

Table 6. *Determinants of changes (1991–99) in proportion of households owning livestock (ordinary least squares regressions).*

Explanatory variable	Oxen	One ox only	Two oxen only	More than two oxen	Heifers	Bulls	Sheep	Goats	Donkeys
Annual rainfall (1000 mm)	–0.016	–0.129	–0.010	0.083	0.139	0.128	–0.225	–0.013	0.042
Altitude (1000 masl.)	–0.001	0.012	–0.027	0.007	–0.094	–0.058	–0.177	0.067	–0.089
Change in proportion of area irrigated	4.946	36.53*	–20.93	–8.732	–2.241	–10.92	–4.392	–16.11*	–27.16***
Distance (100 km) to *woreda* town	–0.288***R	–0.033	–0.181***R	–0.068**	–0.002	–0.007	–0.178	–0.192***R	0.030
Whether there is improvement in access to all weather road	–0.108*R	–0.045	0.008	–0.065	–0.081	–0.079	0.013	–0.056	–0.077
Change in household density (100/km^2)	–0.428	0.144	–0.240	–0.402***R	–0.545***R	–0.678***R	0.272	–0.125	0.383
Change in proportion of households:									
– Credit from ACSI	0.050	0.191	–0.035	–0.112*	–0.248***R	–0.247***	0.103	–0.132	–0.126
– Credit from BoA	0.021	–0.014	0.025	–0.011	0.008	0.044	0.152	–0.042	0.058
– Credit from other formal sources	–0.043	–0.133***	–0.022	0.072***R	0.045	0.030	–0.014	–0.016	–0.003
Change in proportion of adult literates	–0.188	–0.247	0.084	0.103	–0.016	0.047	–0.146	–0.105	0.082
Whether there was land redistribution since 1991	0.176**	0.104***	0.126**R	–0.063***R	–0.018	0.008	0.213**	0.154***R	0.151**
Whether village exclusively manages own grazing land	0.046	0.077*	0.008	–0.022	0.005	0.017	0.075	–0.035	–0.002
Intercept	–0.043	0.045	0.025	–0.053	–0.015	–0.087	0.410*	–0.190	0.055
Number of observations	86	86	86	86	86	86	86	86	86
F-statistic	4.50***	5.23***	2.79**	5.18***	4.82***	2.73**	3.59***	2.27**	5.04***
R^2	0.39	0.29	0.35	0.29	0.32	0.26	0.43	0.28	0.34

Notes: Change in explanatory variable refers to difference between 1991 and 1999 levels. Coefficients and standard errors are adjusted for stratification, weighting and clustering of sample.

*, ** and *** indicate statistical significance at 10, 5 and 1% levels, respectively. R indicates coefficient of same sign and significant at 10% level when predicted values used for changes in proportion of grazing lands with severe erosion, proportion of households using ACSI, BoA and other formal credit, adult literacy, household density and proportion of area irrigated.

Increased proportion of area irrigated generally reduced ownership of livestock, although it was significantly associated with a reduction in ownership of goats and donkeys only and an increase in ownership of only one ox. The general declining trend suggests less reliance on livestock, as we found that, compared with non-irrigated areas, production of cereals, pulses and perishable annuals were more common dominant livelihood strategies in irrigated areas.

Better access to the *woreda* town significantly improved ownership of oxen in general (and two or more oxen in particular) and goats. Improvement in access to all-weather roads, on the other hand, was associated with declining ownership of oxen in general.

Increase in household density was associated with robust reductions in ownership of more than two oxen, heifers and bulls. These findings reflect the increasing pressure on already degraded resources to adequately support large herds of cattle. We also found that increased use of ACSI credit reduced ownership of more than two oxen, heifers and bulls. This was probably due to sale of extra oxen (those additional to the pair needed for ploughing) and young stock to repay loans (fertiliser and improved seed loans) in times of crop failure or to supplement repayment when crop prices were at their lowest, immediately following harvest.[11] Increased use of credit from other formal sources, on the other hand, improved ownership of more than a pair of oxen (while reducing ownership of one ox only). With many NGOs providing credit to farmers for the purchase of livestock, extension efforts emphasising development of improved pasture and forages and veterinary services, more farmers could improve their ownership of a larger herd of cattle.

11. Generally, post-harvest repayment of credit is a problem associated with most agricultural loans.

Land redistribution increased ownership of up to a pair of oxen, small ruminants and donkeys, but reduced ownership of more than two oxen. It seemed that access to own land, which was enhanced through land redistribution, was a major driving force for owning livestock (oxen for ploughing and donkeys for transportation). However, as land redistribution reduced plot sizes and grazing areas and, therefore, the resources to support a large herd, it caused a reduction in the ownership of more than two oxen (either by selling or giving extra ox(en) to newly formed households who acquired land in the redistribution).

The regression models of changes in ownership of cows, calves, horses and mules were not significant and so are not reported.

4.2 Changes in use of feed resources

The determinants of changes in use of various feed sources are shown in Table 7. All of the factors that were hypothesised to affect changes in use of feed resources, except rainfall, altitude, distance to *woreda* town, and changes in household density and proportion of households obtaining credit from BoA had significant impacts on change in use of some feed resource. Increased use of private pastures was associated with an increase in the proportion of area irrigated and communities where land redistribution had taken place. Irrigation allows higher cropping intensity to achieve higher crop yields or production of higher value products. With higher yields from irrigated plots, part of cropland can then be released for private pasture development, especially in areas where part of traditional grazing areas (hillsides and wastelands) has been distributed for cropping and tree planting activities. Decreased use of private pastures, however, was associated with an increase in adult literacy. Perhaps, as education increases, people become more aware and shift to cheaper alternative sources of feed, such as prickly pear, which grows wild in the homestead. Another explanation may be that people diversify into non-farm activities as they become more and more educated.

Table 7. *Determinants of perceived changes since 1991 in use of feed resources, and quality of grazing lands (ordered probit regressions.*

	Sources of feed			Grazing lands	
Explanatory variable	Private pastures	Crop residues	Homestead	Availability	Quality
Annual rainfall (1000 mm)	0.278	–0.777	0.036	1.432	1.489**
Altitude (1000 masl)	0.290	–0.263	0.057	–0.654**	–0.563**
Change in proportion of area irrigated	269.7***R	–84.65	59.19	87.75	11.51
Distance (100 km) to woreda town	–0.363	–0.567	0.577	0.163	–0.353

Whether there is improvement in access to all weather road	–0.586	–1.363***R	–0.219	0.082	–0.342
Change in household density (100/km^2)	–0.134	0.106	0.933	–3.757*R	–4.747***R
Change in proportion of households with:					
– Credit from ACSI	0.077	1.971***	0.451	0.723	–0.070
– Credit from BoA	–0.354	–0.790	0.557	–0.351	0.072
– Credit from other formal sources	–0.353	–0.616*R	0.953**	0.082	–0.686*
Change in proportion of adult literates	–2.654*	0.590	2.982*	1.788*R	0.727
Whether there was land redistribution since 1991	0.554*	0.924***	–0.121	–0.719	–1.201***R
Whether village exclusively manages own grazing land	0.027	0.543**R	–1.893***R	0.705*	0.814***
Number of observations	86	86	86	86	86
F-statistic	2.40**	5.76***	2.99**	1.76*	2.66**

Notes: Change in explanatory variable refers to difference between 1991 and 1999 levels. The dependent variables are ordinal indicators of perceived changes since 1991 where: –2 = decreased significantly; –1 = decreased slightly; 0 = no change; +1 = increased slightly; and +2 = increased significantly. Coefficients and standard errors are adjusted for stratification, weighting and clustering of sample.
*, ** and *** indicate statistical significance at 10, 5 and 1% levels, respectively. R indicates coefficient of same sign and significant at 10% level when predicted values used for changes in proportion of grazing lands with severe erosion, proportion of households using ACSI, BoA and other formal credit, adult literacy, household density and proportion of area irrigated.

Increased use of crop residues was associated with more people obtaining credit from ACSI, where land redistribution has taken place, and where villages manage their own grazing lands. Since ACSI credit is given in kind in the form of chemical fertilisers and improved seed, increasing the proportion of participants can lead to increased intensification of crop production and, subsequently, increase in production of crop residues that can be fed to livestock. With respect to land redistribution, the positive impact may reflect the increased reliance on crop residues for feed due to distribution of traditional grazing areas (mainly between 1996 and 1998) to newly formed households for cropping and tree-planting activities to reduce the growing incidence of landlessness. On the other hand, it may also reflect the positive impact of land redistribution on input use and crop yield, by improving access to land of farmers who are more able and willing to use purchased inputs (Benin and Pender 2001). The positive association between villages managing their own grazing lands and increased use of crop residues may seem counter-intuitive. However, as mentioned earlier, grazing lands managed at the village level are more likely to have grazing restrictions (e.g. grazing at certain times of the year only and/or by certain animals only) imposed on them and for those restrictions to be enforced. Therefore, farmers in such villages have to rely more on crop residues and other sources of feed for their animals during the period of no grazing or for those animals that are not allowed to graze.

We also found that improvement in access to all-weather roads and increase in proportion of households obtaining credit from NGOs were associated with declining use of crop residues. Although improvement in access to markets may induce farmers to produce more vegetables and other cash crops for sale, the crop residues may not be suitable for feeding to livestock. However, they can use part of the income to buy feed, as we found that improvement in access to all-weather roads increases use of purchased feed. As mentioned earlier on, there are many NGOs providing credit and extension for the development of backyard and improved forages. Therefore, the success of these programmes may reduce use of crop residues as feed, since the various feed resources are substitutes.

Increasing use of homestead sources of feed (prickly pear, backyard forages etc.) was associated with increases in proportion of households obtaining credit from other formal sources and proportion of adult literacy. With respect to credit, there were many NGOs involved in the region in providing credit and extension in development of backyard forages. Education, on the other hand, may increase the awareness of people to the benefits of using prickly pear, which commonly grows wild in the homestead and, therefore, is free. We found, however, that declining use of feed from the homestead was associated with villages managing their own grazing lands. These findings again highlight the relative profitability and substitutability of the various feed resources. While crop residues was more important in villages that manage their own grazing lands (discussed earlier), use of feed from the homestead was declining in such villages.

The regression models for changes in use of communal grazing lands and purchased feed, and woodlot/forest areas for fodder were not significant. Therefore, they are not reported.

4.3 Changes in availability and quality of grazing lands

The determinants of changes in the availability and quality of grazing lands are also shown in Table 7.

Change in availability of grazing lands was affected significantly by altitude, changes in household density and proportion of adult literates, and where villages managed their own grazing lands. We found that availability of grazing lands was declining more at higher altitude and where household density had increased more, but was improving more where adult literacy had improved and where villages managed their own grazing lands. The negative effect of altitude and population growth, in addition to the negative association between quality of grazing lands and growth in household density, are consistent with a neo-Malthusian notion regarding the negative impacts of population growth. We also found that household density increased with altitude. Thus, population growth was not inducing sufficient investment in improvement of communal resources to overcome the negative effects of increased pressure on degrading resources. This is consistent with the finding from Tigray (Berhanu et al. 1999) that community natural resources are less likely to be successful in larger communities, due to the difficulties of maintaining collective action in maintenance and use of these resources.

Increase in quality of grazing lands was associated with higher rainfall and where grazing lands were managed at the village level. Generally, ample and reliable rainfall intensity, as observed in the high agricultural potential areas of Gojjam, ensures adequate growth and quick regeneration of lush natural pastures. With respect to community resource management at the village level, since communal grazing lands managed at this lower level are more likely to have grazing restrictions (e.g. grazing at certain times of the year only) imposed on them and for those restrictions to be enforced, their quality will tend to be higher. Quality of grazing lands, on the other hand, declined with elevation, increase in household density, increased use of credit from other formal sources, and where land redistribution had taken place. Generally, in Ethiopia, human and livestock population densities increase with altitude and so the declining quality of grazing lands reflects the increasing pressure on grazing resources, without population growth inducing sufficient communal resource investment to improve the condition of these degrading resources. With respect to the negative impacts of credit, involvement of NGOs in the development of backyard forages may be a contributing factor. There is further increasing pressure on the already degraded grazing resources, where there has been land redistribution, as parts of traditional grazing areas (hillsides and wastelands) are distributed for cropping and tree-planting activities.

4.4 Change in use of animal health services

The determinants of change in the proportion of households using animal health services (vaccines and treatment) are shown in Table 8. Increase in use of animal health services was associated with lower rainfall areas, increase in proportion of area irrigated, better access to the woreda town, increased use of credit from BoA and where land redistribution had taken place. The finding that higher use of health services was associated with lower rainfall areas is counter-intuitive. Poor nutrition may be a confounding factor in developing low resistance to diseases in lower rainfall areas. However, lower rainfall areas face less disease risks, as well as lower agricultural potential and lower incomes. Thus, only some diseases may be more, and purchasing power to use health services will be less. Although the proportions of households using animal health services were more in higher rainfall areas in both 1991 and 1999, the percentage change was more in lower rainfall areas (see Table 3). Poorly managed irrigation projects can become breeding grounds for animal disease vectors and parasites (e.g. worms and ticks) and may therefore increase the incidence of related diseases and, consequently, the demand for health care. On the other hand, people may use more health services in irrigated areas because they have more income and can better afford these services.

Table 8. *Determinants of changes (1991–99) in proportion of households using animal health service, and adoption of improved breeds and stall feeding by communities since 1991.*

Explanatory variable	Use of animal health services	Adoption of	
		Improved breeds	Stall feeding
Annual rainfall (1000 mm)	–1.034*	–2.735**	–2.824
Altitude (1000 masl)	0.260	0.613	0.161
Change in proportion of area irrigated	85.32***	309.2**	–56.83
Distance (100 km) to woreda town	–0.510***[R]	1.679*[R]	–0.079
Whether there is improvement in access to all weather road	0.425	0.000	–0.207
Change in household density (100/km2)	1.503	8.062***[R]	3.422
Change in proportion of households with:			
– Credit from ACSI	0.644	1.824	1.488
– Credit from BoA	0.444*	0.841	1.447

– Credit from other formal sources	–0.111	1.653***	2.510***
Change in proportion of adult literates	–2.084***	3.191	–1.089
Whether there was land redistribution since 1991	0.390*R	1.688***R	2.453***R
Whether village exclusively manages own grazing land	–0.034	–0.466	0.786
Intercept	0.886*	–2.491	–0.177
Type of regression	Censored MLE	Probit	Probit
Number of observations	85	79	86
F-statistic	4.47***	3.22**	2.85**
Notes: Change in explanatory variable refers to difference between 1991 and 1999 levels. For the censored MLE regression, there are 70, 4 and 11 uncensored, left- and right-censored observations, respectively. Coefficients and standard errors are adjusted for stratification, weighting and clustering of sample. *, ** and *** indicate statistical significance at 10, 5 and 1% levels, respectively. R means coefficient of same sign and significant at 10% level when predicted values used for changes in proportion of grazing lands with severe erosion, proportion of households using ACSI, BoA and other formal credit, adult literacy, household density and proportion of area irrigated.			

Better access to the *woreda* town generally improved access to animal health services. Either the farmers walked their animals to the clinic or the farmers visited the clinic to seek advice and/or purchase of drugs, especially with increased access to extension from BoA. With respect to the positive impact where there had been land redistribution, we found that redistribution increased the proportion of households owning livestock (discussed earlier) and, therefore, other things being the same, we expected the proportion of households using health services to also increase.

We found, however, that an increase in adult literacy was associated with a reduction in use of animal health services. The reason for this result is not apparent, as we expected better-educated people to have higher non-farm incomes that could contribute to subsidisation and use of more health services.

4.5 Adoption of improved breeds and stall feeding

The factors affecting adoption of improved livestock breeds and stall feeding are also shown in Table 8. Adoption of improved breeds was associated with an increase in proportion of area irrigated, poor access to the *woreda* town, increases in household density and proportion of households obtaining credit from other formal sources, and where there had been a land redistribution. These findings, except the impact of access to the *woreda* town, jointly suggest that the increasing pressure (population growth, and diminishing plot sizes and grazing areas due to land redistribution) on already degraded grazing resources may be inducing farmers to replace part of their local stock with a smaller number of animals of improved breeds in order to reduce the pressure on resources while improving the productivity of their herds. Providing the impetus for the change are increases in irrigation, which increase development and use of private pastures (as discussed earlier), increase in use of credit from NGOs to purchase improved breeds, and associated extension on development of improved forages and provision of veterinary care. Household data are, however, needed to further test these hypotheses.

The reason for the positive association between poor access to the *woreda* town and adoption of improved breeds is not apparent. It may be that the credit and extension programmes of the NGOs involved in the region are being targeted to more remote areas. In this case, the issue of sustainability (e.g. obtaining the necessary inputs and support services) when such projects come to an end needs to be addressed. Further research is, however, needed to explain the relationship.

The adoption of stall feeding, which was also associated with increase in proportion of households obtaining credit from other formal sources and where there had been a land redistribution, may complement the adoption of improved breeds, as we found that almost 80% of the communities that adopted improved breeds also adopted stall feeding.

5 Conclusions and implications

Using data from a survey conducted in northern Ethiopia, this paper examined the trends since 1991 in the ownership of various types of livestock, use of various livestock feed resources and animal health services, and adoption of improved breeds and modern management practices. We found that ownership of various types of livestock has declined, and that there has been a significant change in utilisation of feed resources: while use of communal grazing lands, private pastures, woodlots and forest areas as feed sources has declined, the proportion of households using crop residues and purchased feed has increased. In addition, the proportion of households using animal health services and the proportion of communities adopting improved livestock breeds and modern management practices (e.g. AI, stall feeding and fattening) have increased. The factors contributing to the trends include agricultural potential, changes in access to markets and participation in credit and extension programmes, population growth, land tenure policy and community natural resource management, as these factors influence the awareness, availability, costs, benefits and risks associated with the different feed resources, technologies and practices, and ownership of livestock.

Irrigation can influence agricultural potential in the Ethiopian highlands (largely dependent on rainfall) allowing development and improvement of private pastures, and improvement of crop productivity. As irrigation combined with improved seeds and fertiliser lead to higher crop yields, other plots, especially the homestead, can be released for forage and pasture development. However, given the limited number of sites providing opportunities for development of irrigation projects, the costs involved and the potential public health problems (e.g. we found that incidence of mosquitoes and malaria was more prevalent in communities with irrigation), their development should be considered on a case-by-case basis.

Better access to *woreda* towns significantly improved ownership of oxen and goats, while improvement in access to all-weather roads reduced ownership of oxen. Improving access to markets and communal management of grazing resources have complex inter-relationships, which in turn have mixed impacts on use of feed resources by influencing the relative importance (and profitability) of feed resources and condition of grazing lands, respectively. Further research on the complex cause–effect relationships is needed to derive policy implications.

Better access to credit and extension, especially those services offered by ACSI and BoA, have not always had positive impacts, probably because credit and extension targeting livestock started only recently. The finding of negative impacts of ACSI credit on livestock ownership needs to be researched further and alternative approaches to credit delivery and collection considered. However, the positive impacts of the credit and extension given by NGOs suggests that the government credit and extension programmes, by adopting the management and delivery strategies of these NGOs, could have similar positive but farther reaching impacts on livestock ownership, since the government programmes are implemented all over the region.

The negative impacts of population growth on ownership of livestock, and availability and quality grazing lands support the Malthusian perspective that rapid population growth contributes to poverty and resource degradation. Efforts to help farmers restock may be critical to poverty alleviation. However, in helping farmers to restock and escape from the downward spiral of poverty, replacement of local stock with fewer animals of improved breeds should be considered since this strategy can reduce the pressure on already degraded resources while improving livestock productivity. To enhance the adoption process, priority should be given to investment in improving access to markets, and credit and extension programmes oriented towards livestock improvement.

Access to own land seems to be a major factor affecting livestock ownership, as land redistribution, which enhanced access to land for many households, had significant positive impacts on ownership of most types of livestock. However, ownership of more than two oxen (i.e. larger herds) was reduced, indicating the negative implications of land redistribution in reducing plot sizes and quality of grazing lands. Nevertheless, it is difficult to continue to use redistribution as a tool to address landlessness because of the very small size of farm holdings and diminishing traditional grazing areas (hillsides and wastelands) in the Ethiopian highlands. Thus, as farm sizes decline making it uneconomical and infeasible for all farmers to try to own at least two oxen, the development of oxen sharing, lease arrangements or other mechanisms for obtaining plough services will become important.

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