Chapter 6

Policies for Livestock Development in the Ethiopian Highlands

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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, nonfood 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. Because of 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). The International Livestock Research Institute (ILRI) and its partners and collaborators have shown that securing the current and future livestock assets of the poor is a major pathway to get the rural poor out of the poverty spiral (ILRI 2002).

In Ethiopia, livestock contribute about 30 to 35 percent of agricultural gross domestic product (GDP) and more than 85 percent of farm cash income. They also contribute about 13 to 16 percent of total GDP. Between 1987–88 and 1995–96, the share of livestock in total exports averaged 16 percent (Degefe and Nega 2000).[1] Ethiopia has the largest livestock population in Africa, which potentially plays an important role in improving food security and alleviating poverty in the region as a whole and in Ethiopia in particular. However, performance in the production of the main food commodities of livestock origin in Ethiopia has been poor compared to other African countries, including neighboring Kenya (Degefe and Nega 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 (Degefe and Nega 2000; Desta et al. 2000), leading to severe losses in times of drought (Webb, von Braun, and Yohannes 1992; Ndikumana et al. 2000).

In 1991, when the present federal government of Ethiopia came to power, it launched, in addition to market liberalization, the Agricultural Development Led Industrialization (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 favor of the latter two over time. Improving the livestock subsector is duly recognized, as 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 preserve and improve indigenous breeds (BOA 1999a).

From a survey conducted in 1999 and 2000 in the highlands of the Amhara region in northern Ethiopia to examine the development of the livestock subsector since 1991, when ADLI was launched, we find that there have been significant changes in utilization of feed resources: although 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, availability and quality of grazing lands have declined. Furthermore, as 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. These changes may not be a matter of concern if they resulted from the rapid expansion of the crop sector or nonfarm sector to make farmers better off. However, data from the same survey and another one conducted in the Tigray region show that there has been little change in livelihood strategies in the northern Ethiopian highlands. Agricultural and crop-livestock production continue to dominate income sources, and several welfare conditions (including average wealth, availability of food, and nutrition of children) have worsened since 1991 (Pender et al. 2001a). The contribution of agriculture to the national economy has remained fairly stable: its share of GDP averaged 53 percent between 1980 and 1991 and 51 percent between 1991 and 1998 (Degefe and Nega 2000), and it employed 86 percent and 82 percent of the labor force in 1990 and 2000, respectively (FAO 2002). Average cereal yield was stagnant, and the incidence of poverty declined only slightly (4.4 percent) in rural areas between 1995 and 2000 (Woldehanna and Alemu 2002).[2] On the other hand, other changes in the national political economy during that period, including, for example, the implementation of the massive agricultural package program leading to substantial increases in the cultivated area under chemical fertilizers and improved seeds, continuing the policy of land redistribution especially in the Amhara region (see Chapter 9 for further discussion), the recurrent drought situation, and rapid population growth, may have affected farm-livestock dynamics and livestock investment decisions and caused the observed changes in the livestock subsector.

The objective of this chapter 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 in order to increase our knowledge of the effect of changes in the socioeconomic and policy environment on livestock keeping and provide information for policy discussions on the use of livestock to get rural people out of the poverty trap. This chapter focuses on the effects on livestock development of similar factors to those considered in Chapters 3, 4, and 5—including agricultural potential, market access, population pressure, and credit—as well as other factors, such as land tenure policies. However, this chapter is significantly different from other chapters in this book in focusing mainly on livestock development and taking a dynamic perspective, considering factors affecting changes in livestock ownership and use of various management practices and technologies. Thus, this chapter is complementary to other chapters in the book, adding a substantially different dimension.

The rest of this chapter is organized as follows. The next section describes the data and then examines trends since 1991 in ownership of various types of livestock, use of livestock feed resources and animal health services, and adoption of improved breeds and modern management practices. The third section presents the empirical framework for analyzing the factors contributing to the trends. Results and discussion are presented in the fourth section, and conclusions and implications are drawn in the fifth.

Data

This research is based on a community-level survey conducted in 98 villages in the Amhara region of northern Ethiopia in 1999–2000, very similar to the community survey conducted in Tigray that was analyzed in Chapter 4. A stratified random sample of 49 peasant associations (PAs)[3] was taken, and two villages were randomly selected from each PA from highland areas (above 1,500 meters above sea level) of the region. Using *woreda* (district) level secondary data, the stratification was based on 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 per square kilometer). Two additional strata were defined for PAs where an irrigation project is present (in drought-prone vs. higher-rainfall areas), resulting in a total of 10 strata. Five PAs were then randomly selected 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 pecent of total area) below 1,500 meters above sea level were excluded from the sample frame.

Information was collected at both PA and village levels using group interviews with about 10 respondents from each PA and village, selected to represent different genders, ages, occupations, and, in the PA-level survey, different villages. Information collected include 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.

Trends since 1991 in the Livestock Subsector in Amhara Region

The Amhara region is located in the northwestern part of Ethiopia. The region covers about one-eighth of the total area of the country and is home to about 27 percent of the total human population (Degefe and Nega 2000) and 35 percent of the total livestock population (BoA 1999b).[4] In the region, livestock and human populations are concentrated in the highland areas, which constitute about 66 percent of the total area (BoA 1999b). Historically, human and livestock settlements have concentrated in the highland areas, especially in the range of 2,300–3,200 meters above sea level (*dega* agroecological zone), because of the relatively good rainfall reliability, cool temperatures, and absence of diseases (e.g., malaria and trypanosomosis).

From the survey conducted in the region, household ownership of livestock has generally declined between 1991 and 1999, with the percentage decrease being larger in drought-prone areas compared to higher-rainfall areas (Table 6.1). The only exception to the declining trend is ownership of donkeys, which increased only 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 northeastern highlands, stretching from northern Shewa

Table 6.1 Proportion of households owning livestock, by agricultural potential

		Sample mean		
Livestock	Location	1991	1999	Percentage change
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.

through Wello into Tigray, and low-lying areas in the southern and southwestern parts, leading to severe food shortage and loss of livestock (Webb, von Braun, and Yohannes 1992). For example, during the 1971–75 drought period, which resulted from a sequence of rain failures, it was estimated that 50 percent of livestock in Wello and Tigray areas alone were lost (Webb, von Braun, and Yohannes 1992). The drought of 1984–85 and the recent one in 2003 have had even greater devastating effects (Webb, von Braun, and Yohannes 1992; FDRE 2003).

With the exception of purchased feed[5] 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 6.2). The increase in use of crop residues was greater in higher-rainfall areas, whereas the 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 6.3). Consistent with the decline in use of communal grazing lands is the perception that both availability and quality have been declining.

Community respondents revealed that use of grazing lands for cropping, settlement, and other nongrazing activities as a result of increasing population pressure has contributed to the decline in availability of grazing lands. Although the highlands account for about 45 percent of the total area of the country, they are home to about 80 percent of the total human population (Degefe and Nega 2000). Rapid population growth (averaging 2.7 percent for the whole country between 1993 and 2001) (FAO 2002) is increasing the demand for farmland and contributing to farming in traditional grazing areas such as hillsides. Restrictions on use of communal resources (e.g., grazing lands, woodlots, and forest areas) for fodder have also contributed to the declining use of these resources. Similar restrictions in use of communal resources are also found in Tigray (Chapter 10). Grazing lands managed at the village level, compared to those managed at the PA level, are more likely to have imposed grazing restrictions (e.g., grazing at certain times of the year only

Table 6.2 Perceived changes since 1991 in use of feed resources and availability and quality of grazing lands, by agricultural potential

	Sample mean		
Resources	**All communities**	**Drought-prone areas**	**Higher-rainfall areas**
Feed sources			
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

Note: Change is an ordinal indicator of perception, where –2 = decreased significantly, –1 = decreased slightly, 0 = no change, +1 = increased slightly, +2 = increased significantly. Sample means are adjusted for stratification, weighting, and clustering of sample.

Table 6.3 Proportion of households buying feed and using animal health services, by agricultural potential

Assistance	Location	Sample mean 1991	Sample mean 1999	Percentage change
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.

and/or certain animals only) and for those restrictions to be enforced. With respect to the decline in use of private pastures, about 45 percent of the communities reported conversion of private pastures into cropland because of shortage of farmland. 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) and adoption of improved breeds (especially of cattle and small ruminants) and modern management practices (artificial insemination, stall feeding, and fattening) have increased since 1991 (Tables 6.3 and 6.4). The proportion of households using health services increased by almost twofold between 1991 and 1999. Although the proportion of households using health services is higher in higher-rainfall areas, the proportionate increase between 1991 and 1999 in drought-prone areas is almost double that in higher-rainfall areas. Common health problems, in order of importance, revealed by community respondents include anthrax, black leg, contagious bovine pleuropneumonia, pasteurellosis, parasites, rinderpest, trypanosomosis, sheep and goat pox, and African horse sickness. Adoption of improved breeds and stall-feeding practices since 1991 are more common than adoption of artificial insemination and fattening practices. Stall-feeding practice is twice as common in higher-rainfall

Table 6.4 Proportion of communities (with some of their residents) adopting improved breeds and modern livestock management practices since 1991, by agricultural potential

Practice	All communities	Drought-prone areas	Higher-rainfall areas
Improved breeds	0.26	0.28	0.25
Artificial insemination	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.

areas than in the drought-prone areas, whereas fattening practices are undertaken exclusively in low-rainfall areas.

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 2000a), and the number of vaccinations and treatments increased by 33 percent from 5.4 million in 1993–94 to 7.2 million in 1997–98 (BoPED 1998, 1999). Traditionally, credit and associated extension focused on crop production to the neglect of the livestock subsector. However, there are now many nongovernmental organizations (NGOs) involved in the region providing credit for purchasing livestock, extension on improved forage development, and veterinary services.[6] In addition, compared to past programs, the current 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, and natural resource management and postharvest technology.[7] Furthermore, a revolving credit program especially to address livestock and other long-term investment activities has been instituted by the regional government. This credit fund is granted from various bilateral and multilateral organizations and administered by the Bureau of Agriculture (Wondafrash, Grace, and Assefa 1998).

Because livestock are very important to the livelihood of farmers engaged in mixed crop–livestock farming systems in the highlands, a declining trend in ownership of livestock is cause for worry, 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.

Econometric Approach

We have five types of dependent variables: (1) changes in ownership of livestock; (2) changes in use of feed resources; (3) changes in availability and quality of grazing lands; (4) changes in use of animal health services and purchased feed; and (5) adoption of improved livestock breeds and modern management practices. Depending on the type of dependent variable, different econometric techniques are utilized. However, the general econometric model to be estimated is given by the first-difference model[8]

$$\Delta y_v = a_2 - a_1 + b(x_{v2} - x_{v1}) + (c_2 - c_1)z_v + e_{v2} - e_{v1} \quad (6.1)$$

where Δy_v represents the dependent variable in village v, x_{vt} the vector of observed time-varying factors affecting Δy, z_v the vector of observed fixed factors affecting Δy, and e_{vt} are unobservable factors affecting Δy. The observed fixed factors, z_v, will have an influence 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 utilized to estimate them. Then the explanatory variables used in the estimations are presented.

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 are interested in the differences in the proportions between 1999 and 1991. We use ordinary least squares to estimate the factors affecting the differences in the proportions because there was no censoring of the dependent variables (i.e., the proportions were never zero or one in any village). Different types of livestock are examined because each type has different functions in the farming system. Primarily, oxen are used for plowing, cows for milk, young cattle (bulls and heifers) for food and herd replacement, small ruminants and poultry for cash, and equines for transport. With respect to oxen, the ownership is further disaggregated into the proportion of households owning one ox only, two oxen only, and more than two oxen. Households without oxen have to rely entirely on others through rentals or borrowing, which can severely affect the timeliness of cultivation and subsequent crop yields. Those with one ox only are better off because they can pair up with their neighbors in a similar situation, whereas those with two oxen can be deemed self-sufficient in their plowing needs. Households with more than two oxen can rent out plowing services to other needy farmers to generate additional income. In general, the disaggregation helps to provide as much information as possible.

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.

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 are calculated here are censored. For example, if the proportion of households buying feed was one in 1999, then the dependent variable was right censored. On the other hand, if the proportion of households buying feed was zero in 1999, then the dependent variable was left censored. Therefore, we estimate 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 at the 10 percent level, and so it is not reported.

Adoption of Improved Livestock Breeds and Modern Management Practices

Survey respondents revealed whether or not some of the residents of the community had adopted improved livestock breeds,[9] artificial insemination, stall feeding, or fattening practices since 1991. We use probit regression models to estimate the factors affecting the probability of adopting these technologies, where the dependent variable is one if some residents have adopted and zero otherwise. Because only 5 percent and 3 percent of the communities reported having some of their residents adopting artificial insemination and fattening practices, respectively, there was not enough variation in the respective binary dependent variables to estimate the adoption of these management practices.

Explanatory Variables and Hypotheses

We expect that changes in feed use, adoption of livestock technologies, and change in ownership of livestock will 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 programs, education, and community natural resource management (Pender, Scherr, and Durón 1999; Desta et al. 2000; Pender et al. 2001a; Chapter 2). These factors influence the awareness, availability, costs, benefits, and risks associated with the different livestock technologies and management practices and livestock ownership.

Increase in population pressure can reduce the availability and quality of grazing resources. Although better market access can increase the use of purchased feed, it can reduce the use of crop residues, as farmers may shift to producing less cereals and more marketable crops (e.g., vegetables) whose residues may not be suitable for livestock. Better market access may also increase use of health services and adoption of improved breeds through increased availability of those technologies and facilitating use of cash income from sale of crops to finance 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 fertilizer), and adoption of stall feeding and use of health services (through extension services).

Regarding the effects of land tenure policy, the main issue is land redistribution, which has been frequent and ongoing since 1975 (instituted by the military government) to reduce landlessness and equalize landholdings and quality across households. Although land redistribution was stopped in many regions of Ethiopia in 1991 (with the current government coming to power), it continued in many parts of the Amhara region. A major recent redistribution exercise in the region took place in 1996–97, raising the proportion of farmers who owned land. However, actual implementation, type and amount of land affected, and population affected were not uniform across the region, as the exercise was left to local officials for needs assessment and implementation. In general, the exercise drew a massive reaction, both against and in support of it. See Chapter 9 for further discussion on the policy, its implementation, reaction to it, and expected effects on land investments and productivity. By improving farmers' access to land, land redistribution can increase ownership of livestock by smallholders. On the other hand, by reducing field size for supporting livestock, land redistribution may reduce ownership. Community management of grazing lands is expected to increase availability and quality of grazing lands (Gebremedhin, Pender, and Tesfay 2004; Chapter 10).

Table 6.5 shows a description of the explanatory variables used in the analyses and their means and standard errors. Agricultural potential is measured by average annual rainfall (with a mean of 1,217 millimeters), altitude (2,182 meters above sea level), and change in proportion of area irrigated (0.04 percent). Access to markets is measured by distance to the *woreda* town (37 kilometers) and whether there has been an improvement in access to an all-weather road (5 percent).[10] The other explanatory variables are population growth, which is measured by change in number of households per square kilometer (11), changes in proportion of households obtaining credit (and associated extension services) from BoA (20 percent), ACSI (9 percent),[11] and other formal sources (e.g., NGOs, 19 percent), change in adult literacy (15 percent), whether there has been land redistribution since 1991 (49 percent), and whether villages manage their own grazing lands (39 percent). Note that the above changes, unless otherwise stated, refer to the difference between 1999 and 1991 levels.

One econometric problem to address here is that several of the time-varying explanatory variables may be endogenous. Population growth, change in participation

Table 6.5 Means and standard errors of explanatory variables

Explanatory variable	Mean	Standard error
Annual rainfall (×1,000 millimeters)	1.2177	0.0312
Altitude (×1,000 meters above sea level)	2.1824	0.0809
Change in proportion of area irrigated	0.0004	0.0002
Distance (×100 kilometers) to *woreda* town	0.3739	0.0569
Whether there is improvement in access to all-weather road	0.0527	0.0267
Change in household density (×100/km^2)	0.1107	0.0169
Change in proportion of households with:		
Credit from ACSI	0.0890	0.0300
Credit from BoA	0.1988	0.0674
Credit from other formal sources (e.g., NGOs)	0.1880	0.0715
Change in proportion of adult literates	0.1446	0.0159
Whether there was land redistribution since 1991	0.4879	0.0673
Whether village exclusively manages own grazing land	0.3909	0.0782

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

in credit and associated extension programs, change in area irrigated, and change in adult literacy 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).[12] We failed to reject exogeneity of those 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 those potentially endogenous variables.

Results

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

Changes in Ownership of Livestock

Table 6.6 shows the factors affecting changes in the proportions of households owing livestock. With respect to oxen, it is further broken down into ownership of one ox only, two oxen only, and more than two oxen. Among the factors that were hypothesized to affect changes in ownership of livestock, rainfall, altitude, changes in proportion of households obtaining credit from BoA, and adult literacy have no statistically significant effect on change in ownership of any type of livestock. Our finding of a limited association of rainfall and altitude with changes in livestock ownership contrasts with results for Tigray in Chapter 4, in which ownership of

Table 6.6 Determinants of changes in proportion of households owning livestock, 1991 to 1999

Explanatory variable	Oxen	One ox only	Two oxen only	More than two oxen	Heifers	Bulls	Sheep	Goats	Donkeys
Annual rainfall (×1,000 millimeters)	–0.016	–0.129	–0.010	0.083	0.139	0.128	–0.225	–0.013	0.042
Altitude (×1,000 meters above sea level)	–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 kilometers) 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/km²)	–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

Note: Ordinary least-squares regressions. Change in explanatory variable refers to difference between 1999 and 1991 levels. Coefficients and standard errors are adjusted for stratification, weighting, and clustering of sample.

***, **, and *** indicate statistical significance at 10 percent, 5 percent, and 1 percent levels, respectively.**

[R]Coefficient of same sign and significant at 10 percent level when predicted values used for changes in proportion of households using ACSI, BoA, and other formal credit, adult literacy, household density, and proportion of area irrigated.

oxen was found to be greater in higher-rainfall areas, and cows and goats less common, but sheep more common, at higher altitude. These differences may reflect the fact that factors influencing differences in *levels* of livestock ownership were investigated in Chapter 4, whereas we are investigating differences in *changes* in livestock ownership. Both sets of results may be consistent with each other; for example, it may be that ox ownership is generally greater in higher-rainfall areas but also be true that changes in ox ownership are not.[13]

Increase in proportion of area irrigated generally is associated with a reduction in ownership of livestock, although it is statistically significantly associated with a reduction in ownership of goats and donkeys only and an increase in ownership of one ox. The general declining trend suggests less reliance on livestock as we find that, compared to nonirrigated areas, production of cereals, pulses, and perishable annuals are more common dominant livelihood strategies in irrigated areas.

Better access to the *woreda* town is associated with an increase in 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, is associated with a decline in ownership of oxen in general. This latter result is consistent with the findings of Chapter 4.[14]

Increase in household density is 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 and are similar to the results of Chapter 4, which found higher population density associated with less ownership of oxen. We also find that increase in use of ACSI credit reduces ownership of more than two oxen, heifers, and bulls. This is probably a result of sale of extra oxen (more than the pair that is needed for plowing) and young stock to repay loans (fertilizer and improved seed) in times of crop failure or to supplement repayment when crop prices are at their lowest, immediately following harvest.[15] Increase in use of credit from other formal sources, on the other hand, is associated with an increase in ownership of more than a pair of oxen (while reducing ownership of only one ox). With many NGOs providing credit to farmers for the purchase of livestock, extension efforts emphasizing development of improved pasture and forages, and veterinary services, more farmers can improve their ownership of a larger herd of cattle.

Land redistribution is associated with increases in ownership of up to a pair of oxen, small ruminants, and donkeys, but a reduction in ownership of more than two oxen. It seems that access to own land, which is enhanced through land redistribution, is a major driving force for owning livestock (oxen for plowing and donkeys for transportation). However, as land redistribution reduces plot sizes and grazing areas and, therefore, the resources to support a large herd, it causes a reduction in the ownership of more than two oxen (either by selling or gifting extra oxen 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 statistically significant, and so they are not reported.

Changes in Use of Feed Resources

The determinants of changes in use of various feed sources are shown in Table 6.7. Several factors have statistically significant effects on change in use of some feed resource. Increase in use of private pastures is positively affected by an increase in the proportion of area irrigated and in areas where land redistribution has 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 waste lands) has been distributed for cropping and tree-planting activities. Decreased use of private pastures, however, is 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 nonfarm activities as they become more educated.

Increase in use of crop residues is positively affected by increased use of credit from ACSI, where land redistribution has taken place, and where villages manage their own grazing lands. Because ACSI credit is given in kind in the form of chemical fertilizers and improved seed, increasing the proportion of participants can lead to increased intensification of crop production and, subsequently, increased production of crop residues that can be fed to livestock. With respect to land redistribution, the positive influence may be reflecting the increased reliance on crop residues for feed as a result of 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 effect of land redistribution on input use and crop yield by improving access to land by 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 counterintuitive. 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 or for 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.

Table 6.7 Determinants of perceived changes since 1991 in use of feed resources and availability and quality of grazing lands

	Sources of feed			Grazing lands	
Explanatory variable	**Private pastures**	**Crop residues**	**Homestead**	**Availability**	**Quality**
Annual rainfall (×1,000 millimeters)	0.278	–0.777	0.036	1.432	1.489**
Altitude (×1,000 meters above sea level)	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 kilometers) 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**

Note: Ordered probit regressions. Change in explanatory variable refers to difference between 1999 and 1991 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, +2 = increased significantly. Coefficients and standard errors are adjusted for stratification, weighting, and clustering of sample.

***, **, and *** indicate statistical significance at 10 percent, 5 percent, and 1 percent levels, respectively.**

[R]Coefficient of same sign and significant at 10 percent level when predicted values used for changes in proportion of households using ACSI, BoA, and other formal credit, adult literacy, household density, and proportion of area irrigated.

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

Increase in use of homestead sources of feed (prickly pear, backyard forages, etc.) is positively affected by increases in proportion of households obtaining credit from other formal sources and adult literacy. With respect to credit, there are many NGOs involved in the region who are providing credit as well as extension in development of backyard forages. This influence is likely more a result of the effects of extension than of credit, per se. Education, on the other hand, may increase farmers' awareness of the benefits of using prickly pear, which commonly grows wild in the homestead and, therefore, is free. However, decline in use of feed from the homestead is greater where villages manage their own grazing lands. These findings again highlight the relative profitability and substitutability of the various feed resources.

The regression models of changes in use of purchased feed, communal grazing lands, and woodlot or forest areas for fodder were not statistically significant at the 10 percent level. Therefore, they are not reported.

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 6.7. Change in availability of grazing lands is significantly affected by altitude and changes in household density and proportion of adult literates, and where villages manage their own grazing lands. We find that availability of grazing lands has declined more at higher altitudes and where household density has increased more but improved more where adult literacy has improved and where villages manage their own grazing lands. The negative effects of altitude and population growth are consistent with a neo-Malthusian notion regarding the negative effects of population growth. We also find that household density increases with altitude. Thus, population growth is 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 (Gebremedhin, Pender, and Tesfay 2004; Chapter 10) that community natural resource management is less likely to be successful in densely populated communities because of difficulties of maintaining collective action in maintenance and use of those resources.

Increased quality of grazing lands is positively affected by rainfall and is also seen where grazing lands are managed at the village level. Generally, ample and reliable rainfall intensity, as observed in the high-agricultural-potential areas of the western Amhara region, ensures adequate growth and quick regeneration of lush natural pastures. With respect to community resource management at the village level, because communal grazing lands managed at this lower level are more likely to have grazing restrictions 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, has declined more at higher elevations, where household density and use of credit from other formal sources have increased and where land redistribution has taken place. Generally, human settlement increases with altitude, and so the declining quality of grazing lands reflects the increasing pressure on grazing resources if population growth does not induce sufficient communal resource investment to improve the condition of those degrading resources. With respect to the negative effects of credit, involvement of NGOs in the development of backyard forages may be a contributing factor. There is additional increasing pressure on the already degraded grazing resources where there has been land redistribution because parts of traditional grazing areas (hillsides and waste lands) are distributed for cropping and tree-planting activities, and more farmers are able to own livestock, as discussed earlier.

Change in Use of Animal Health Services

The determinants of change in the proportion of households using animal health services (vaccine and treatment) are shown in Table 6.8. Increase in use of animal health services is negatively affected by rainfall but positively affected by increase in proportion of area irrigated, better access to the *woreda* town, increase in use of credit from BoA, and a history of local land redistribution.[16] The finding that higher use of health services is associated with lower-rainfall areas is counterintuitive. Nutrition may be a confounding factor in developing low resistance to diseases in lower-rainfall areas. However, lower-rainfall areas face less disease risk as well as lower agricultural potential and lower incomes. Thus, only some diseases may be more common in lower rainfall areas, and purchasing power to use health services will be less. Note, however, that the proportion of households using animal health services was greater in higher-rainfall areas in both 1991 and 1999, though the percentage increase was greater in lower-rainfall areas (Table 6.3). Poorly managed irrigation projects can become breeding grounds for animal disease vectors and

Table 6.8 Determinants of changes (1991 to 1999) in proportion of households using animal health services and adoption of improved breeds and stall feeding by communities since 1991

		Adoption of	
Explanatory variable	Use of animal health services	Improved livestock breeds	Stall feeding
Annual rainfall (×1,000 millimeters)	–1.034*	–2.735**	–2.824
Altitude (×1,000 meters above sea level)	0.260	0.613	0.161
Change in proportion of area irrigated	85.32***	309.2**	–56.83
Distance (×100 kilometers) 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/km^2)	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**

Note: Change in explanatory variable refers to difference between 1999 and 1991 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 percent, 5 percent, and 1 percent levels, respectively.**

[R]Coefficient of same sign and significant at 10 percent level when predicted values used for changes in proportion of households using ACSI, BoA, and other formal credit, adult literacy, household density, and proportion of area irrigated.

parasites (e.g., worms and ticks) and may therefore increase the incidence of related diseases and, consequently, 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 it.

Better access to the *woreda* town generally improves access to health services, either by walking animals to the clinic or going to seek advice or purchase drugs, especially with increased access to extension from BoA. With respect to the positive influence where there has been land redistribution, we find that redistribution increases the proportion of households owning livestock (discussed earlier) and, therefore, other things being the same, we would expect the proportion of households using health services to also increase.

The results show that an increase in adult literacy is associated with a reduction in use of animal health services. The reason for this result is not apparent, as we expect better-educated people to have higher nonfarm income that can contribute to financing and using more health services.

Adoption of Improved Livestock Breeds and Stall Feeding

The factors affecting adoption of improved livestock breeds and stall feeding are also shown in Table 6.8. Adoption of improved breeds is positively affected by an increase in the proportion of area irrigated, increase in household density, increase in proportion of households obtaining credit from other formal sources, and where there has been a land redistribution but negatively affected by access to the *woreda* town. These findings, except the effect of access to the *woreda* town, jointly suggest that the increasing pressure (population growth and diminishing plot sizes and grazing areas as a result of land redistribution) on already degraded grazing resources may be inducing farmers to replace part of their local stock with fewer improved breeds in order to reduce the pressure on resources while improving the productivity of their herd. Although substantial added investment may be required to replace a larger herd of local animals with a smaller herd of local and improved animals, evidence suggests that the return on investment can be very high. For example, crossbred cows used for production of both milk and traction can produce about six times more milk than local cows and plow a plot of farmland faster than local oxen, and the return on investment can be as high as 78 percent (GebreWold, Misgina, and Shapiro 1998). Providing the impetus for the change are increase in irrigation, which promotes development and use of private pastures (as discussed earlier), and 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, however, are needed to further test these hypotheses.

The reason for the negative association between better access to the *woreda* town and adoption of improved livestock breeds is not apparent. It may be that the credit and extension programs of those 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,[17] which is also positively affected by an increase in the proportion of households obtaining credit from other formal sources and by a history of land redistribution, appears to complement the adoption of improved breeds, as we find that almost 80 percent of the communities that adopted improved breeds also adopted stall feeding.[18]

Conclusions and Implications

Using data from a survey conducted in northern Ethiopia, this chapter 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 have been significant changes in utilization of feed resources: although 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., artificial insemination, 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 programs, population growth, land redistribution, and community natural resource management, as these factors influence the awareness, availability, costs, benefits, and risks associated with owning livestock and with the use of different feed sources, technologies, and practices.

Irrigation can influence the agricultural potential in the Ethiopian highlands, largely dependent on rainfall, to develop and improve private pastures while improving crop productivity. As irrigation, combined with improved seeds and fertilizer, lead to higher crop yields, other plots, especially the homestead, can be released for forage and pasture development. In fact, an ambitious program to tap the irrigation potential in the Ethiopian highlands was developed under the Sustainable Agriculture and Environmental Rehabilitation Program. In Amhara region alone, for example, the program initially planned to construct 540 microdams to irrigate 62,000 hectares over 10 years (CoSAERAR 1999). However, the plans have been scaled back as a result of capacity constraints and assessment of the availability of suitable sites. Given the limited opportunities for development of irrigation projects, the costs involved, and potential public health problems, as the data show that incidence of mosquitoes and malaria were more prevalent in communities with irrigation (see also Haile et al. 2003), their development should be considered on a case-by-case basis.

Better access to *woreda* towns significantly improves ownership of oxen and goats, whereas improvement in access to all-weather roads reduces ownership of oxen. Improving access to markets and communal management of grazing resources have complex interrelationships, which in turn have mixed influences 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, given that access to infrastructure has improved very little over the years. For example, in the early 1980s, it was found that about three-fourths of highland farm households lived more than a six-hour walk from an all-weather road (FAO 1986). Nearly two decades later, the average distance is about a five-hour walk (Pender et al. 2001a).

Better access to credit and extension, especially those offered by the Amhara Credit and Savings Institution (ACSI) and the Bureau of Agriculture (BoA), have not had positive influences across the board, probably because credit and extension targeting livestock started only recently. The finding of negative effects of ACSI credit on livestock ownership needs to be researched further, and alternative approaches to credit delivery and collection considered. However, the positive effects of the credit and extension given by NGOs suggests that the government credit and extension programs, by adopting the management and delivery strategies of those NGOs involved, can have similar positive but farther-reaching effects on livestock ownership because the government programs are implemented all over the region.

The negative effects of rapid population growth on ownership of livestock and availability and quality of 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 get out of the downward spiral, replacing some local stock with fewer improved breeds to reduce herd size and stocking rate should be considered because this strategy can reduce the pressure on the 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 programs oriented toward livestock improvement.

Access to land seems to be a major factor affecting livestock ownership, as land redistribution, which enhanced access to land for many households, had significant positive effects on ownership of most types of livestock. However, ownership of more than two oxen (larger herd) was reduced, indicating the negative implications of land redistribution by 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 waste lands) in the Ethiopian highlands. Thus, developing oxen sharing, lease arrangements, or other mechanisms for obtaining plow services will become important as farm sizes continue to decline.

Notes

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1. The share of livestock in total exports, however, declined from 21.3 percent in 1987–88 to 12.9 percent in 1995–96, with hides and skins contributing about 93 percent of total livestock exports within this period (Degefe and Nega 2000). There is similar evidence of the importance of livestock to the livelihoods of farmers in other Sub-Saharan African countries. For example, in the greater horn of Africa (comprising Ethiopia, Kenya, Somalia, Tanzania, and Uganda), it is estimated that livestock provide 20 to 30 percent of GDP and about 70 percent of farm cash income (Ndikumana et al. 2000). See for example ILCA (1987), USDA (1990), and Gittinger et al. (1990) for other estimates.

2. Poverty actually increased in urban areas by 11 percent within the same period (Woldehanna and Alemu 2002).

3. Peasant associations are the lowest-level local government in Ethiopia and usually consist of three to five villages.

4. Compared to other regions, Amhara stands first in number of goats; second in cattle, sheep, asses, horses, and poultry; and fifth in camels (CSA 1998).

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

6. See Desta et al. (2000) for details on NGO activities in the region.

7. PADETES was launched in the country in 1994.

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

9. These include mainly indigenous animals improved through breeding or selection as well as crossbred animals.

10. We had wanted to use the change between 1999 and 1991 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 1 refers to either a reduction in walking time between 1991 and 1999 or access in 1999 where access did not exist in 1991, and 0 otherwise.

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

12. The instrumental variables used to predict the potentially endogenous explanatory variables, in addition to the exogenous variables in the regressions, include the values of each those endogenous variables in 1991: walking time to 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.

13. Note from the first difference econometric model described in equation (6.1) that the coefficient of fixed variables such as rainfall and elevation do not represent the same thing as a coefficient in a cross-sectional model; instead, the coefficient of fixed variables represent the change in coefficient that would apply at a given point in time. By contrast, the coefficients of changes in explanatory variables in the first difference model (such as changes in access to roads) should reflect the same coefficients as in a cross-sectional model, assuming that coefficients do not change between the two time periods in the first difference model.

14. As noted in the previous endnote, the coefficient of change in road access in a first difference model should be consistent with the coefficient of road access in a cross-sectional model, whereas the coefficient of a fixed variable such as distance to the nearest town would not be the same in cross-sectional and first difference models.

15. Generally, postharvest repayment of credit is a problem associated with most agricultural loans.

16. In Chapter 4, rainfall and market access were found to have insignificant association with use of vaccination services. The difference between that finding and ours could be for the same reason explained in note 14.

17. Stall feeding is commonly used when raising improved livestock breeds, especially dairy animals.

18. The positive association of stall feeding with access to some types of NGO credit contrasts with results in Chapter 4, where the authors found a negative association of NGO credit with improved feeding practices. This difference may reflect differences in the focus of NGO credit programs as well as differences in response variables (changes vs. levels), as noted previously.