Chapter 3 Livestock Production Systems and their Environmental Implications in Ethiopia

Tom Kimball

Research Highlights

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Environmental Policy Review 2011: Livestock Production Systems and their Environmental Implications in Ethiopia

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Tom Kimball
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- How do expanding livestock production systems and increasing numbers of cattle impact the quantity and quality of rangeland and forest cover in Ethiopia?
- Spatial, qualitative and quantitative data were used to frame and analyze livestock production and impacts.
- Livestock production is underestimated in its contribution to GDP and undervalued in its benefits and worth to rural Ethiopians.
- Ethiopia is highly dependent on livestock: as its population grows, so does its livestock production.
- Substantial increases in livestock production have negative externalities on the environment including erosion, soil degradation, GHG emissions, deforestation, and water pollution.
- Livestock is underestimated both as an asset and as a potential threat to Ethiopia.
- With support from research institutes, NGOs and international development partners, Ethiopia should increase productivity per animal through improved genetics, feed, and services and minimize negative environmental externalities by engaging in nutrient management strategies, selective grazing patterns, and carbon sequestration efforts.

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Environmental Policy Review 2011: Livestock Production Systems and their Environmental Implications in Ethiopia

By Tom Kimball

Executive Summary

"Livestock Production Systems and their Environmental Implications in Ethiopia" is the third chapter in *Environmental Policy Review 2011*, a report produced by the Environmental Policy Group in the Environmental Studies Program at Colby College in Waterville, Maine.

As an agricultural country with a low level of economic development, livestock are estimated to contribute to the livelihoods of 60-70% of the population of Ethiopia. Subsequently, the Ethiopian livestock herd is the largest of any African nation. Livestock help perform a wide variety of functions for Ethiopians and are among the most important commodities of the country.

This chapter uses spatial, qualitative and quantitative data to explore the current trends of livestock production and their environmental externalities. The production systems for livestock are framed with GIS mapping and literature review. The value and production of livestock are quantitatively analyzed, as are their effects through quantitative data and meta-analysis. Policy recommendations are informed via interviews and literature review.

Just as Ethiopia's population is growing at a rapid rate, so too is the country's total number of livestock. The environmental impacts of livestock production in Ethiopia include but are not limited to erosion, soil degradation, GHG emissions, water pollution, and deforestation. These impacts have inherent feedback loops which compound one another's effects.

Current trends related to expanding agriculture and livestock in Ethiopia, such as deforestation and other forms of land degradation, are a high level risk to the improvement living standards within the country. In order to combat these trends of environmental degradation, Ethiopia must create a comprehensive, feasible livestock production policy promoting efficiency and reducing the environmental impact of livestock production in order to successfully handle the growing numbers of the livestock population.

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Introduction

Environmental degradation from human pressures and land use has become a major worldwide problem, though the effects are felt more in developing countries due to the high population growth rate and the associated rapid depletion of natural resources (Ehrlich, 1988). Ethiopia is a largely agricultural country whose economy is based on renewable resources in rural areas. Given the low level of economic development in the country, the pressure exerted on the environment by growing human and livestock populations has exacerbated the rapid depletion of the natural resource base (Feoli, et al. 2002). The issue of livestock and the production systems that support them is of the utmost significance if Ethiopia is to improve its social and economic stability.

The Scope of Livestock

Throughout their long history, Ethiopians have constantly relied on livestock in order to survive. Livestock in Ethiopia are extremely important as they serve a wide variety of functions in society from social to subsistence purposes (Behnke, 2010; Kassahun, 2008; Halderman, 2004). Livestock in Sub-Saharan Africa and in Ethiopia are often undervalued in terms of their potential for supporting overall economic development, poverty alleviation, and the general well-being of an immense proportion of the population. In spite of the relatively low notice they are afforded, livestock are estimated to contribute to the livelihoods of 60-70% of the Ethiopian population (Halderman, 2004). They can contribute in a myriad of different forms from traditional security systems to cash to transportation for many Ethiopians. As the oldest form of assets in Ethiopia, cattle and other types of livestock have traditionally and still today serve as a significant indicator of wealth. Even today, Ethiopia is generally recognized to have the largest population of livestock of any other African nation (Halderman, 2004). The immense scope of dependence on livestock is not without reason; Ethiopia's population is growing at a tremendous rate of 2.56% as of 2010 (World Bank, 2011). As rural Ethiopians, generally speaking, live in a subsistence economy, the immense pressure of that population growth has exacerbated poverty, leaving the population more vulnerable to hunger, disease, and famine. Ethiopia's dependency on livestock has in turn created a need to expand livestock production, to help feed and support the growing population. The environmental burden that comes with this intensive increase in livestock production is substantial. The conversion of woodlands and shrublands into croplands has resulted in the loss of the natural vegetation cover and has caused serious erosion (Feoli et al., 2002).

Livestock and Deforestation

Environmental degradation as a result of agricultural development occurs in a numerous forms. One of the most devastating and widespread is deforestation. Removing forest and crop residues adversely affects the continued productivity in both forest and agricultural systems. It is important to note the scale of deforestation in Ethiopia to date. Forest areas have been reduced from 40% of land cover a century ago to an estimated less than 3% (Bishaw, 2001). A major issue within forestry throughout Ethiopia's history has been property rights. From the 1950s until 1974, private land ownership was promoted through land grants given by the federal government. As a result, mechanized farming became increasingly attractive, and large numbers of Ethiopians were relocated to forest areas, where recent pressures have forced unsustainable harvest of timber and other forest products. The Derg regime, which took power after the Ethiopian Revolution in 1974, worsened the situation by promoting relocation programs known as "villagization". Deforestation and the resulting environmental degradation has remained a major problem in Ethiopia and a key challenge to food security, community livelihood and sustainable development. Between 1955 and 1979, over 77% of the country's forested area disappeared, and Ethiopia continues to lose 140,000 hectares of its remaining forests annually (Winberg, 2010).

There is no doubt of the interdependency of agriculture and healthy woodlands. Tree and crop residues contain valuable nutrients that are lost to the soils once they are removed. The removal of trees and other land cover also exposes soil to the consequences of water and wind erosion (Pimentel et al., 1986). For a country that has only 3% of its original forests still standing, and where 80% of people depend on wood fuel for all of their energy needs, continued deforestation is a serious issue. Losing forest cover as a result of agricultural expansion is a severe risk for Ethiopia in both sustaining its main energy source as well as its environmental health.

Objectives

This report asks the question:

> How do expanding livestock production systems and increasing numbers of cattle impact the quantity and quality of rangeland and forest cover in Ethiopia?

In addressing this question, this report seeks to:

- understand the importance of livestock production systems and their impact on pastoral communities in Ethiopia;
- assess the trends and extent of degradation to the environment in Ethiopia as a result of livestock production systems; and
- document constraints, coping methods, and policy recommendations for the future of livestock production in Ethiopia.

Methods

In order to assess livestock production systems and their effects on rangeland and forest ecosystems, I began with an extensive literature review of scientific reports conducted on livestock production systems within Sub-Saharan Africa and, more specifically, Ethiopia. The initial review served to introduce and frame the issue of environmental degradation caused by livestock in Ethiopia. I then used spatial, qualitative and quantitative data to explore the importance of livestock production systems, the environmental degradation these systems cause, and policy measures that could alleviate the pressures of livestock on the Ethiopian environment.

Spatial Data

Using Geographic Information Systems (GIS) analysis with ArcMap 10, I generated a land-use cover map to see how agricultural development has affected forest areas across Ethiopia. The GIS map used in this report was generated using GlobCover 2009 land cover data, which was derived from a time series of global MERIS FR mosaics for the year 2009. A layer displaying elevation within Ethiopia was then added onto the land cover map to illustrate the relationships between land use and topography. Scientific literature on land cover and use in Ethiopia was used to further clarify how livestock production and grazing might affect the different land cover patterns observed through GIS mapping.

Qualitative Data

Due to resource and time constraints, conducting a survey of livestock herders in Ethiopia specific to this report was not possible. There is, however, extensive scientific literature discussing local perceptions of expanding livestock production and environmental degradation (see, e.g., Ayantunde, 2011; Agassa et al., 2008; Kassahun, 2008 among others). A large amount of qualitative data concerning Ethiopian livestock was derived from FAO and IGAD Working Papers (PPLPI Working Paper No. 19 & IGAD LPI Working Paper No. 07-08). These papers focused on regulatory frameworks, economic issues, and policy recommendations for livestock production systems in Ethiopia. Other important qualitative data gathered were interviews with representatives of ILRI and correspondence with MoARD and FAO representatives.

Quantitative Data

A primary source for quantitative data in this report was the FAOSTAT database, which provides time-series and cross sectional data relating to food and agriculture for over 200 countries, including Ethiopia. The data on livestock were reported in 'live head,' referring to an estimation of grazing livestock not yet slaughtered for meat or other processing. Data were selected for analysis, transferred to Microsoft Excel, and presented in appropriate figures. Bivariate analysis and linear

regression were then used to look for significant predictors of livestock increases and dependency. A series of IGAD Working Papers provided estimates of the contribution of livestock to the Ethiopian economy (IGAD LPI Working Paper No. 02-11, 2010), while measures of environmental impacts of livestock in broader terms were obtained from the Evans School Environmental Implications of Livestock Series, published in 2011.

The study findings presented below are organized as follows:

- Laws, Institutions, and Stakeholders
- Geographic Distribution of Livestock
- Growing Numbers of Livestock
- Economic Importance of Livestock
- Environmental Implications of Livestock
- Long-Term Impacts and Interview Findings

Laws, Institutions, and Stakeholders

Ethiopia has a number of laws providing for sanitary and food safety standards, as well as the prevention of animal diseases that affect livestock production. Whether these laws are enforced is questionable. Government policies have been unabe to provide relevant infrastructure and market development to enforce administration policies (Forum for Environment, 2011).

Table 3.1 Livestock-related laws, MoARD, 2011.

Law	Year	Description	Location of Law
Livestock and Meat Board Order No. 34/1964	1964	Set up Livestock and Meat Board and the establishment of a National Veterinary Institute	N/A
Meat Inspection Proclamation No. 274	1970	Set up formal specifications for slaughterhouses and other processing facilities	Federal Negarit Gazeta, 29th Year, No. 15, 6th April 1970
Meat Inspection Regulations No. 428	1972	Set official federal standards for meat inspection and food safety.	Federal Negarit Gazeta, 32nd Year, No. 14, 13th November 1972
Animal Diseases Prevention and Control Proclamation No. 267	2002	Law providing for the prevention and control of animal diseases, and further sanitary standards	Federal Negarit Gazeta, 8th Year No. 14, 31st January 2002
Reorganization of the Executive Organs of the Federal Democratic Republic of Ethiopia (Amendment) Proclamation No. 380	2004	Dissolved the Livestock Marketing Authority (1998) and all duties into MoARD. MoARD as it exists today is created, merging the Ministry of Agriculture with Rural Development	Federal Negarit Gazeta, 10th Year No. 15, 13th January 2004

Federal Institutions

The key national institution for livestock production systems in Ethiopia as well as forest management is the Ministry of Agriculture and Rural Development (MoARD). MoARD is the government ministry charged with overseeing agricultural and rural development policies in Ethiopia. Within the many varied responsibilities of MoARD are the following two duties: supervising use and conservation of forest resources, as well as monitoring and promoting agricultural development.

MoARD was originally the Ministry of Agriculture, which was established by the Federal Government of Ethiopia with the passing of Proclamation 4-1995. This Proclamation also established the other 14 original Ministries of the Federal Democratic Republic of Ethiopia. On January 13, 2004, Proclamation No. 300/2004 merged the Ministry of Agriculture with the Ministry of Rural Development, which today comprises MoARD.

As it pertains to forestry, MoARD operates under the Forest Development, Conservation and Utilization Proclamation No. 542/2007. The Proclamation recognizes two forest types: private and state owned. The Proclamation also bequeaths MoARD with various powers and duties. They include: differentiating trees vs. plants, identifying endangered indigenous tree species, coordinating relevant federal and regional bodies, and enacting policies, laws and strategies to effectively utilize and conserve Ethiopian forests. MoARD also provides technical support to all relevant federal and regional bodies. In forestry today, MoARD acts upon Proclamation No. 542/2007: Forest Development, Conservation and Utilization. This Proclamation replaces the Policy and Strategy on Forest Development, Conservation and Utilization issued by Ministry of Agriculture and Rural Development, which was adopted by the Council of Ministers in 1997.

The Ministry of Finance and Economic Development (MoFED) is another institution with ties to the livestock sector in Ethiopia. It was established to initiate policies that ensure sustainable and equitable macroeconomic stability in Ethiopia. As it relates to livestock, MoFED is responsible for generating GDP estimates for all sectors of the Ethiopian economy. The reports generated by MoFED are thus critical in understanding livestock's role within the economy of Ethiopia. By the same token, if GDP estimates are incorrect (as some authors have argued (IGAD, 2010)) the valuation and subsequently the prioritization of livestock within the Ethiopian economy may be erroneous.

The Ministry of Health is the other important player in the livestock sector, especially as related to any food products derived from livestock. Within the Ministry laws, Article 22 requires the Ministry of Health to devise plans and follow up on their implementation in eradicating communicable diseases, undertaking the necessary quarantine controls to protect public health, and conducting studies with a view to determining the nutritional value of foods.

Finally, the Environmental Protection Authority is the primary regulatory agency for environmental protection in Ethiopia. At the regional and lower levels, the Environmental Protection and Land Administration Authorities act as regulatory agencies for environmental regulation. One of the most important is the Environmental Policy of Ethiopia (Forum for Environment, 2011). This policy addresses a wide range of environmental concerns. The major aim of the policy is to ensure the sustainable use and management of natural, human made and cultural resources, and the environment. The specific land use and administration policies and strategies have been developed by the different Regional States with autonomous organizations established for implementation (Forum for the Environment, 2011).

International Projects, Stakeholders, and NGOs

There are a variety of institutions invested in Ethiopian livestock production in some way. The Intergovernmental Authority on Development (IGAD), comprised of Djibouti, Eritrea, Ethiopia, Kenya, Somalia, Sudan and Uganda, has implemented the IGAD Livestock Policy Initiative (LPI). The LPI's purpose is to promote sustainable and effective livestock practices within IGAD countries. To this end, the initiative has created a number of IGAD Working Papers, designed to explore issues related to livestock development in the context of poverty alleviation.

Pastoralists Forum Ethiopia (PFE) is comprised of 20 members, including: Panos Ethiopia, Pastoralist Concern Association Ethiopia, Farm Africa, Hope for the Horn, Oxfam GB, SOS Sahel, UN-EUE. NGOs such as PFE campaigned to have pastoralists' ties included in documents such as the PRSP. From these efforts, the PRSP, published in 2002, contains a section on development approaches and interventions in pastoral areas. However, the document does not include the first and most basic recommendations from PFE, which was that pastoralism be recognized as a way of life and as a production system in the same way that traditional peasant cropping systems are recognized by the federal government (Halderman, 2004).

With 60-70% of the population's livelihoods dependent on livestock in one way or another, the majority of Ethiopians are stakeholders in the success of the livestock sector, and in the environmental systems that support livestock production (Behnke, 2010; Halderman, 2004). The most reliant on livestock can be classified into two groups; those living in the rural highland areas, and those in the pastoral lowland communities. While the majority of people and livestock live in the rural highlands, pastoralists rely more on livestock than any other population category (Ayantunde et al., 2011; Halderman, 2004). The vast majority of land users and managers in Ethiopia, whether in the highlands or pasturelands, also have a stake in any land management practices that affect livestock. The farmers and local communities are the direct beneficiaries, and ultimately the enforcers, of the environmental policies seeking to mitigate the environmental impacts of livestock management in Ethiopia.

Study Findings

Geographic Distribution of Livestock

Land use displayed by GIS mapping in Figure 3.3 show different applications of livestock within Ethiopia. The GIS map was derived from the GlobCover 2009 land use data. Classifications 11-30 (irrigated croplands, rainfed croplands, mosaic croplands/vegetation, mosaic vegetation/croplands) are all considered cultivated areas or managed lands (see Appendix 3A for details). The elevation layer shows that the Ethiopian rural highlands (classified as >1500m) contain nearly all cultivated or managed areas, classified as land use 20 and 30. These areas show livestock use in order to aid in plowing and cultivating cereal crops for Ethiopia. As elevation drops around the cultivated areas, much of the land classification turns to mosaic forest shrubland and grassland, which is where livestock are connected within the pastoral production system.

The figure emphasizes in particular those agricultural areas that are bordering forests, as indicated by the shift in red and orange, which represent croplands and livestock managed areas in the Ethiopian Highlands, to the shades of greens representing various classifications of forest and shrublands. This puts into perspective (1) the sharp contrast in land use in the Highlands versus other areas in Ethiopia, and (2) the ongoing encroachment of croplands and pasturelands into forested areas.

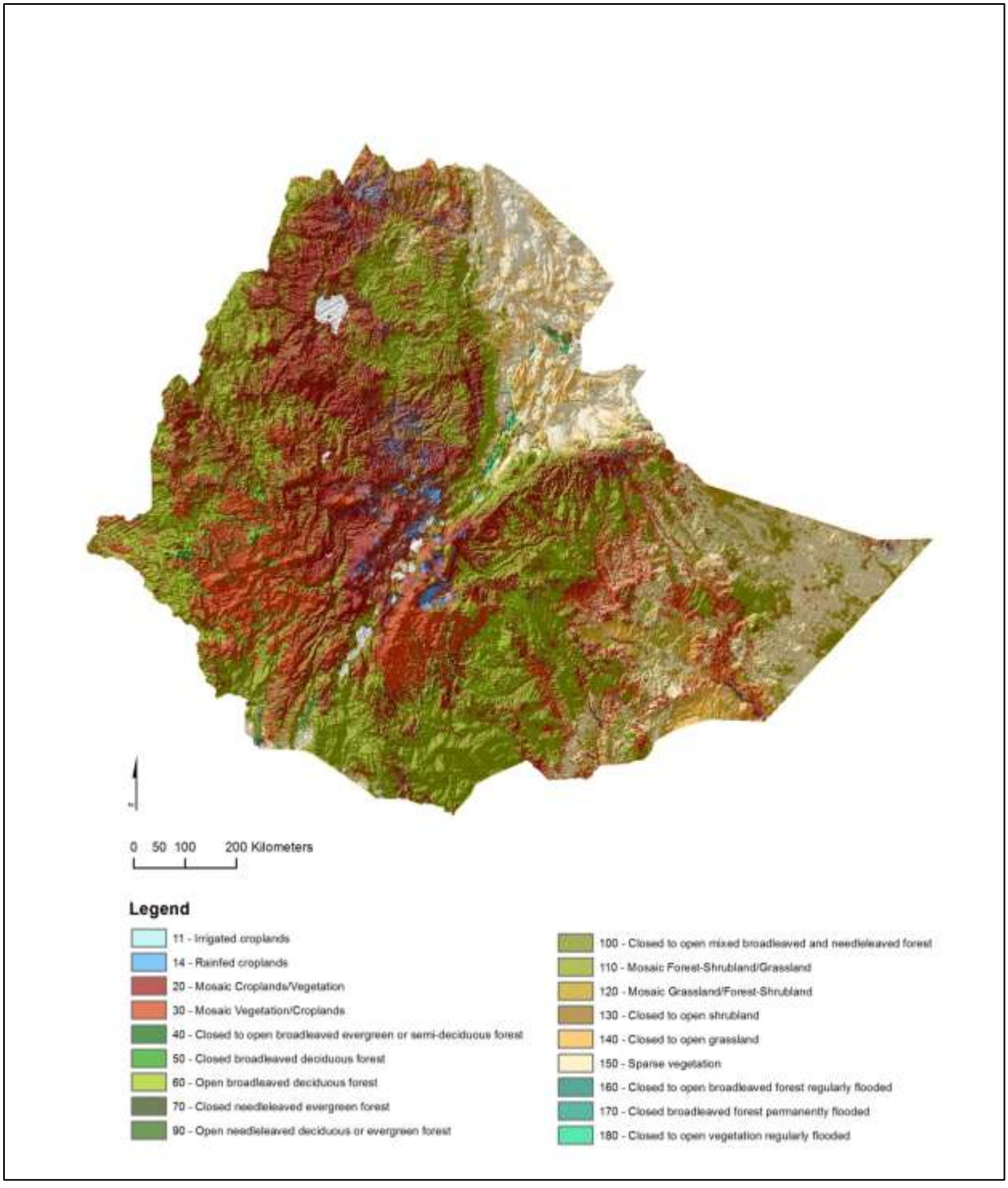

Figure 3.1 Land-use GIS map with elevation.

As shown in Figure 3.1, the rural highlands of Ethiopia are classified as over 1500m above sea level, while pastoral areas are classified as under 1500m above sea level. Table 3.2 shows the estimates for livestock distributions among the two areas, according to the FAO's Pro-Poor Livestock Policy Initiative Working Paper 19. The largest change in livestock with regard to elevation is cattle, which are far more prevalent in the Highlands (aside from camels, which are not present at all in the rural Highland areas).

Table 3.2 Distribution of livestock in Highland and pastoral areas.

	Rural Highland Areas	Pastoral Areas
Cattle	70-80%	20-30%
Sheep	48-75%	25-52%
Goats	27-55%	45-73%
Camels	none	100%

Table 3.2 Notes: Highlands are defined as areas over 1500 meters above sea level, pastoral areas are less than 1500 meters above sea level. Data from PPLPI Working Paper No. 19.

Growing Numbers of Livestock

Quantitative Results

There is a relatively steady increase in nearly all types of livestock in Ethiopia from the year 2000 through 2009. An exception is chickens, which from the years 2002-2005 declined, and in 2009 fell just short of the peak in 2002.

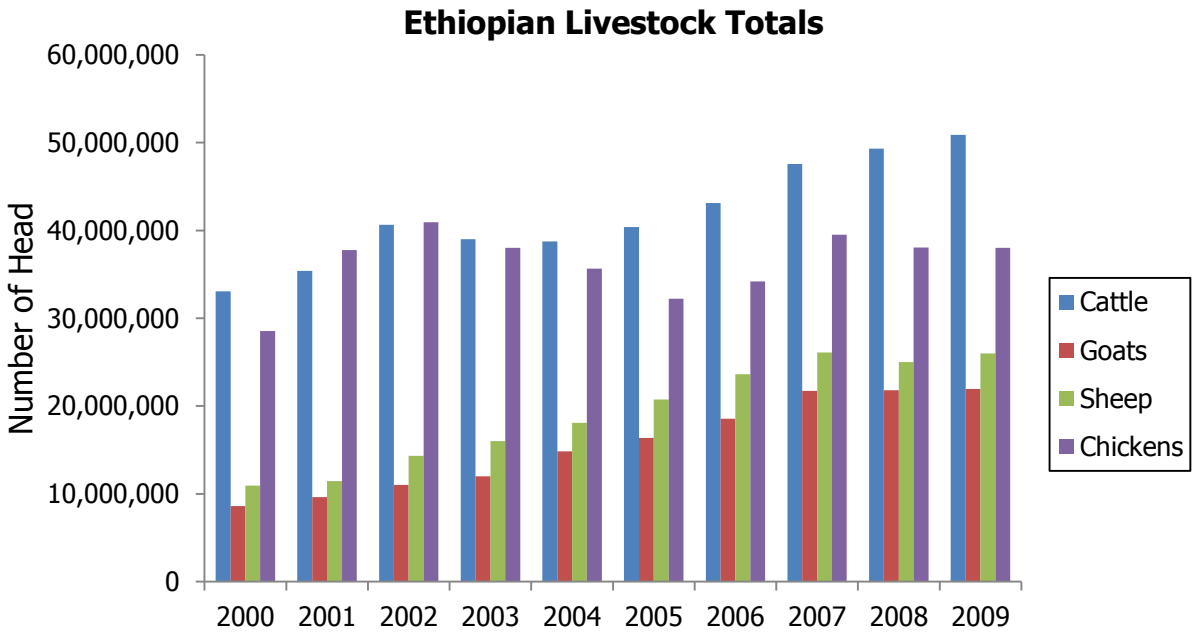

Figure 3.2 Comparison of main types of Ethiopian livestock though 2000-2009. Data obtained through FAOSTAT.

The trends seen in Figure 3.3 show an overall constant expansion in the total number of animals (despite the decrease in chicken totals). It should be noted that cattle in Ethiopia started and remained as the largest total, despite the large amount of resources required to keep them relative to other forms of livestock.

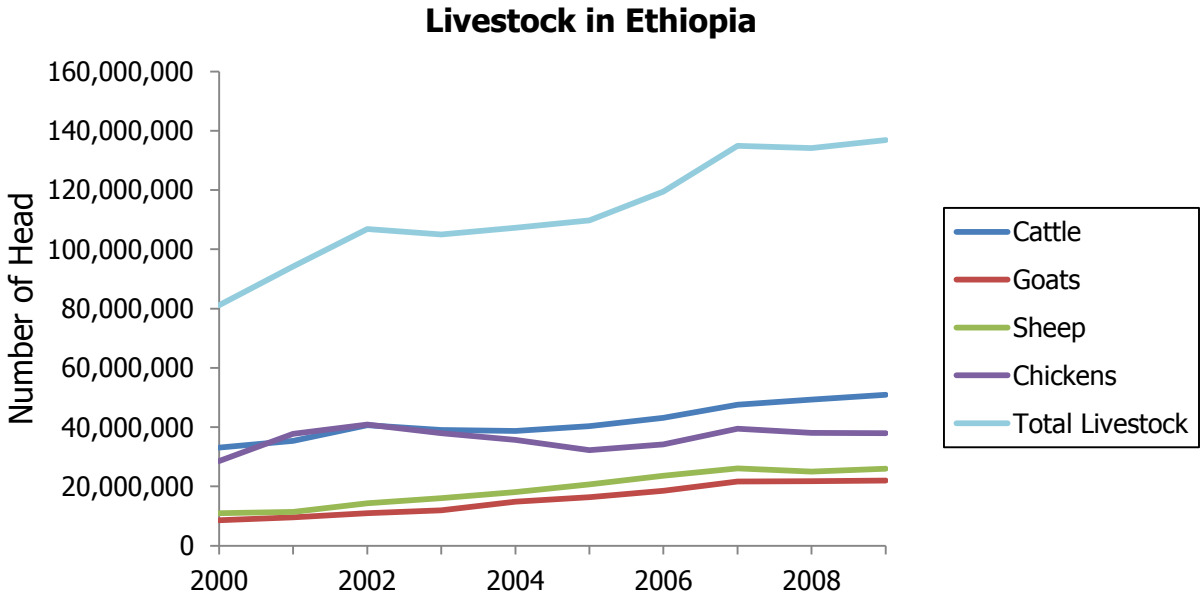

Figure 3.3 Comparing trends in totals of livestock head, with a sum total added. Data obtained through FAOSTAT.

The regression line seen in Figure 3.4 shows the linear increase in the total number of cattle on average, per year with an R-squared value of 0.9287. The line represents that on average, 5,858,280 additional cattle, chickens and sheep are found in Ethiopia each year.

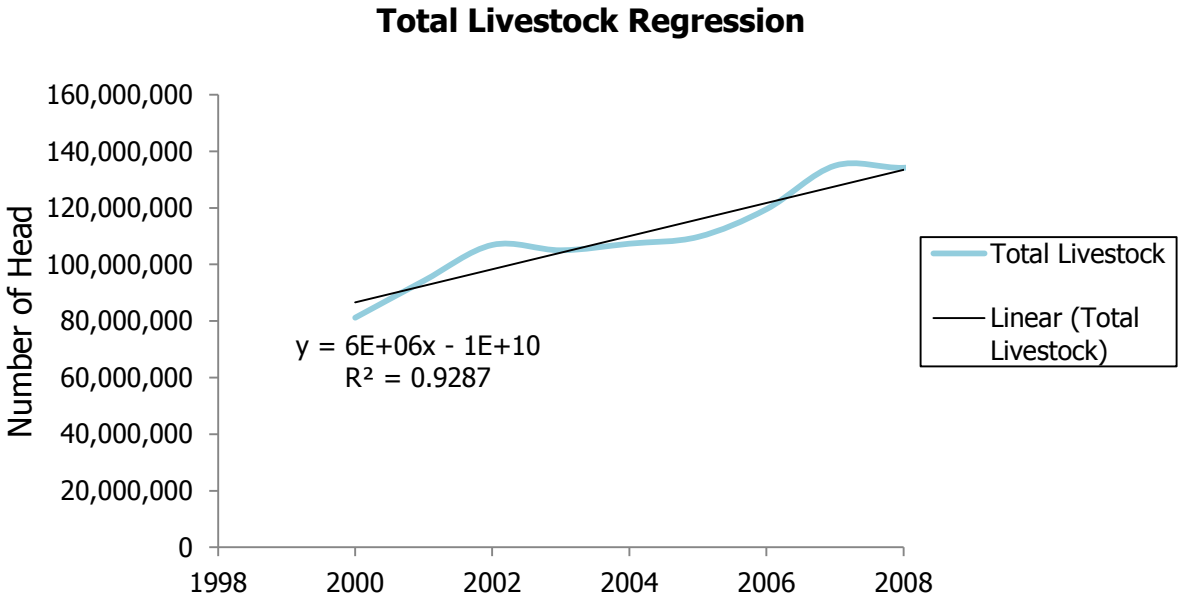

Figure 3.4 Regression line derived from the total additional head of livestock per year. Data obtained through FAOSTAT.

Figure 3.5 illustrates land use trends in Ethiopia with respect to agricultural and forested areas using data from the FAO. The forest area is at a nearly constant decline of 141,000 hectares from 2000-2009, while area devoted to agriculture rises every year except from 2007-2008. Though agricultural areas include both areas devoted to crops those devoted to livestock, nearly all small-scale crop cultivation in Ethiopia is driven by livestock to some degree as discussed further below.

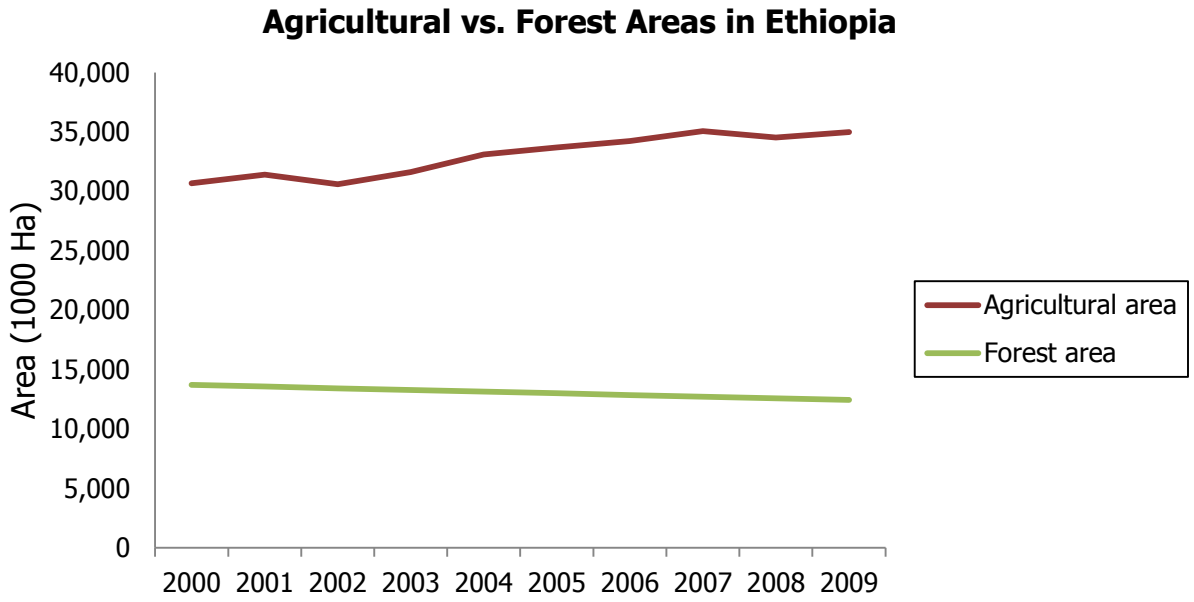

Figure 3.5 Total land devoted to agriculture and forest cover in Ethiopia. Data obtained through FAOSTAT.

Economic Importance of Livestock

Livestock Contribution to GDP

There is a complex system of indicators used to quantify and measure livestock production's impact on Ethiopian national GDP. The livestock sector is estimated to contribute 30-35% of annual GDP, according to the government estimates of MOFED (Halderman, 2004). However, livestock specialists frequently argue that livestock production is underrepresented in the GDP estimates of African nations. Part of the problem is caused by deficiencies in data and estimation procedures, although even accurate counts of the number of livestock raised may still leave livestock underrepresented in terms of their contribution to national GDP (Behnke, 2010). Including for the value of plowing and other underestimated services outlined below in Table 3.3, the IGAD has re-estimated the economic importance of livestock to show that livestock provided more than 45% of agricultural GDP in 2008-09 (Behnke, 2010).

Table 3.3 Livelihood benefits derived from ruminant and equine livestock, 2008-09 in billion Ethiopian birr

Type of benefit	Agricultural GDP	Services not in current GDP estimates
Value added livestock products (meat, milk, etc)	MOFED: 32.232 re-estimated: 47.687	
Traction power for ploughing		21.500
Benefit from financing		12.800
Benefit from self-insurance		8.600
Benefit from risk pooling/stock sharing		3.650
Transport and haulage by equines*		18.959*
Sub-totals	47.687	65.590
Total economic benefits	113.196	

Table 3.3 Notes: Data from IGAD LPI Working Paper No. 02 – 11, *refers to 2009-10.

Shown in Table 3.3, the total economic benefits of livestock goods and services may be more than 113 billion Ethiopian birr, which is over three times greater than MOFED's standard GDP estimate (IGAD, 2010). This new estimate puts into perspective how vital livestock are to the Ethiopian economy, not only in terms of their product value, but their wide array of services as well. The importance of livestock and the undervaluation of their services are summed up in the following excerpt from a recent IGAD working paper:

> If Ethiopian farmers and herders provision themselves with home produced goods, they also in large measure service themselves. The most important services provided by livestock include the supply of animal power (for traction, transport and haulage), and livestock as a source of financial services (as providers of credit, as a form of self-insurance and as a means of sharing or pooling risk). According to international conventions, the value of this self-servicing is not separately itemized in national accounts and therefore cannot be identified as part of the economic benefits that livestock provide (IGAD LPI Working Paper No. 02-11, 2010, p. 36).

This conclusion is reinforced by CSA surveys that estimate the value of home-produced livestock food products at 70% of total household expenditures on livestock foods. The great bulk of the meat and milk products that Ethiopians eat are not processed or traded outside the home (IGAD, 2010).

Table 3.4 displays the asset composition of Ethiopian households in a survey of 1,477 different households. Livestock were found in 78% of the households, second only to farm tools and implements. Livestock's mean value was exorbitantly larger than any other asset in the Ethiopian household.

Table 3.4 Asset compositions from 1994 survey across 1477 households.

Assets	Mean value in birr	Number of households	% sampled households
Livestock	2,181	1,154	78
Farm tools and implements	49	1,307	89
Wooden and other furniture	112	1,100	75
Cooking materials	140	345	23
Radio, tape, jewelry, watch	66	305	21
Guns, spear, etc.	158	186	13
Cart	535	18	1.2
'Gotera' (grain storage basket)	391	6	0.4
Others	120	22	1.5
Sampled households		1,477	
Holders of bank accounts		12	0.8

Table 3.4 Notes: While the coverage of the formal banking system has in all probability improved since 1994 when this data was collected, there is little evidence to suggest that livestock importance drastically declined from 1994 until today. Data taken from IGAD LPI Working Paper No. 02-11.

Environmental Implications of Livestock

Figure 3.6 depicts the overall theoretical framework used in conducting the literature review and meta-analysis to evaluate the environmental impacts of livestock in Ethiopia.

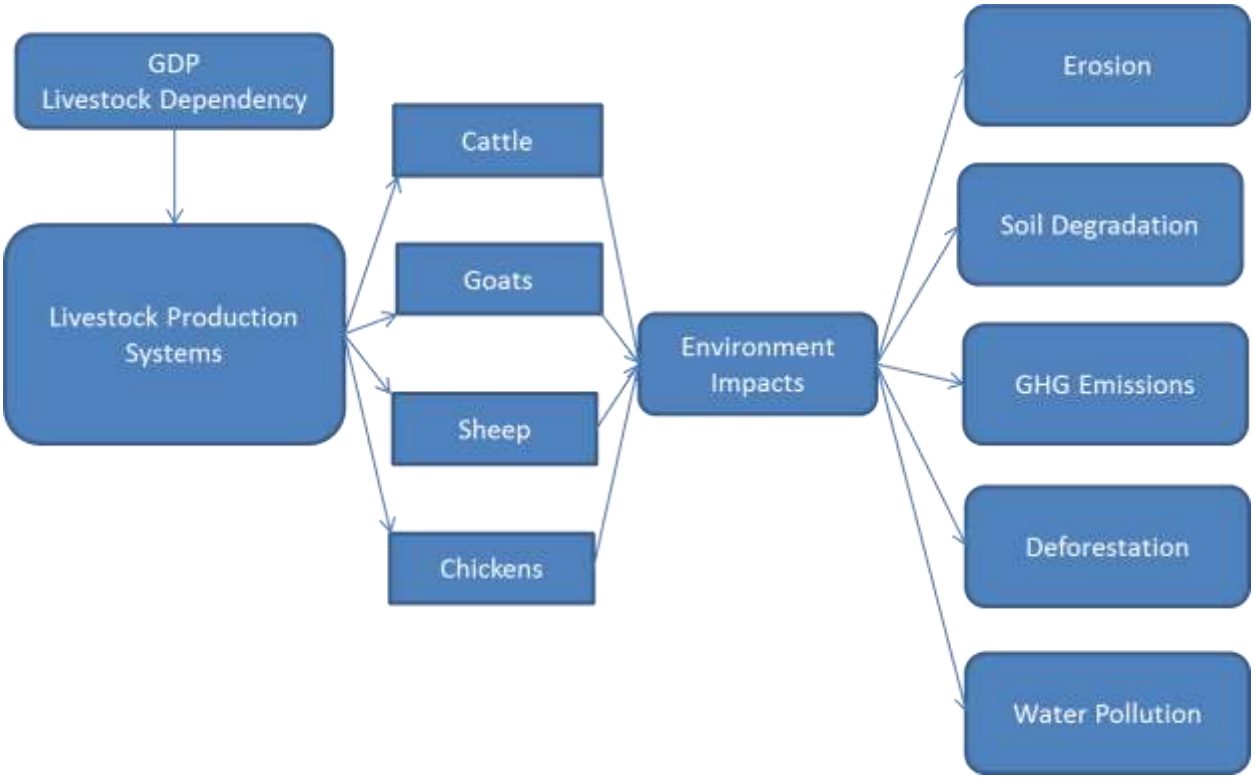

Figure 3.6 Systems diagram of livestock production systems and their environmental impacts.

The major livestock production systems in Ethiopia which include cattle, goats, sheep, chicken, and other livestock systems, cause multiple environmental impacts including erosion, soil degradation (reduction in soil quality and supported vegetation), greenhouse gas (GHG) emissions, deforestation, and water pollution (and in the longer term, flow reduction).

Furthermore, such environmental impacts can have a large amount of feedback loops, an example of which is depicted in Figure 3.7. In this case, livestock production systems initiate the loop by causing deforestation due to cropland expansion. Deforestation then leaves the soil vulnerable to water and wind erosion, which removes surface materials and nutrients. Erosion then leads to further soil degradation, as tree and crop residues contain valuable nutrients that are lost to the soils once they are removed. And finally, the eroding soils and nutrients are lost into the water table and into the streams, rivers and ponds that the entire production system and surrounding ecosystems depend on.

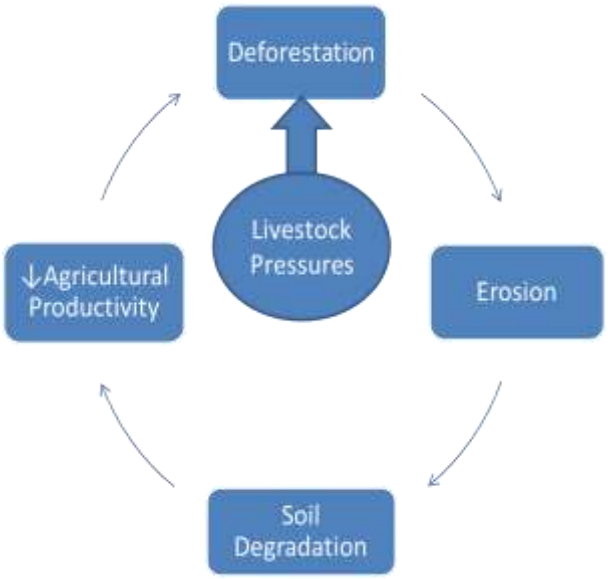

Figure 3.7 Feedback loop of deforestation due to livestock pressures.

Specific environmental implications of livestock encountered in the literature are summarized below.

GHG Impacts

The greenhouse gas output for livestock in developing countries are laid out in Figure 3.6, which was compiled from data found in the *Environmental Implication of Livestock* series. Methane is a potent greenhouse gas with a global warming potency of more than 20 times that of carbon dioxide (IPCC, 2007). Nitrous oxide emissions, whose primary source is manure management, have more than 300 times the global warming potential of carbon dioxide. Ruminants, including cattle, goats and sheep, emit greater amounts of methane during their digestive process than do monogastrics (chickens).

Chickens are the most efficient livestock in Ethiopia in terms of producing the most meat and protein per amount of greenhouse gases emitted (Lipson et al., 2011).

Table 3.5 Environmental implications of livestock in developing countries, Lipson et al., 2011.

	Methane Emissions (per head, annually)	Nitrogen	% of Nitrogen volatized	Other
Cattle	Dairy: 46-58kg Other: 27-31kg Manure: 6-5kg	27-31 kg	22-50%	Ammonia, nitrogen oxides and nitrogen gas. GHG emissions, land/water pollutants
Chickens	0.02 kg	0.6-1.1 kg	50-55%	Chickens most efficient, meat and protein/GHGs
Goats	5 kg Manure: 0.11-0.22 kg	1.37 kg	15-35%	Volatization leads to ozone and aerosols

Vegetation Impacts

The main vegetation impacts derived from Environmental Implications of Livestock Series include:

- Livestock grazing and trampling have marked effects on vegetative cover, soil quality and nutrient loss due to erosion. Evidence of this impact is found in the 10-20% of grasslands worldwide that are degraded due to overgrazing.
- Overgrazing of pastureland causes soil erosion and releases carbon from decaying organic matter, compacting wet soils and disrupting dry soils. The effects of trampling depend on soil type.
- Desertification due to overgrazing causes a loss of 8-12 tons of carbon per hectare from soils and 10-16 tons of carbon in above-ground vegetation. In mixed farm systems, land tillage and crop production further compound the loss of native vegetative cover and leads to soil erosion, while soil compaction and soil disruption result in increased runoff and erosion.
- Livestock grazing and trampling have marked effects on vegetative cover, soil quality and nutrient loss due to erosion (Lipson et al., 2011).

Interviews

Several attempts were made to contact the Ministry of Agriculture and Rural Development (MoARD), including phone calls on four different publicly listed numbers for the Ministry during regular business hours. Of those four, only one attempt was successful, but the contact did not respond to the follow up questions via e-mail or telephone, thus limited data were obtained.

Notes from a phone interview with Dirk Hoekstra, Project Manager for ILRI projects in Ethiopia are summarized below.

What is Ethiopia's major policy and international assistance aims for the livestock sector?

Governmental goals for the livestock sector focus on improving productivity, which will indirectly improve the per-animal environmental impacts by providing a more productive base (the same amount of erosion per cow, but less erosion per kilo of meat or per liter of milk).

Major livestock problems:
*Genetic problems (e.g., low quality breeding stock, disease)
* Fodder availability and fodder quality
* Veterinary services (access & quality)
* Marketing

These challenges are compounded by the presence of two very different livestock systems in Ethiopia - the pastoral system, and the mixed crop-livestock systems of Highland Ethiopia.

There is also rising concern over the question of how to maintain livestock production levels in the face of climate change. ILRI's recent "Livestock Exchange" online contains presentations on adapting the livestock sector to climate change in the future.

Discussion

The data gathered in this chapter highlight that human-induced land degradation is a significant problem in Ethiopia, and that livestock production is among the most significant driving forces. It is necessary to have a clear understanding of the pressures that livestock place on the availability of natural resources, and on the rural agricultural system as a whole.

Importance of Livestock

With regard to the importance of Ethiopian livestock production in Ethiopia, there was significant overlap throughout the literature review. Most prominently the two sets of working papers conducted by partner organizations, the FAO and the IGAD, had extremely consistent findings on

this issue. While the IGAD working papers focused on the quantitative measures of livestock's contribution to GDP in Ethiopia, they acknowledged the diverse functions that livestock fulfill in Ethiopia. Many of these functions are displayed in Table 3.3. Indeed, part of the IGAD working paper's purpose was to quantify some of these functions, such as plowing for increased crop productivity. Arguably the most important way to understand the importance of livestock in Ethiopia across existing literature is asset accumulation. Not only can livestock serve as the most common form of assets (cash), but they can also help fill the institutional vacuum created by the absence of formal financial institutions in rural Ethiopia (IGAD, 2010). Livestock can function as a form of credit in rural areas, giving owners access to economic resources represented by livestock potential without having to borrow money and pay interest (IGAD, 2010). Another value of livestock as credit defined by both sets of working papers is the form of security against risk that livestock offer (in the absence of insurance companies, premiums, or claims). Because the value of livestock in rural Ethiopia is not established by market exchanges, economics cannot attribute the amount of credit and insurance that should be attributed to livestock.

There are still ways in which to further quantify the immense value of Ethiopia's livestock. Figures 3.3 and 3.4 quantitatively show the importance of livestock in Ethiopian livestock in broad economic terms, and relative to other household items. It is clear from both sets of data that livestock play a central role in both the Ethiopian economy and as an asset for individual households. In terms of their contribution to GDP and household assets, livestock should be considered a crucial element in Ethiopia's economy and social well-being.

Rural Highlands vs. Pastoral Areas

The land use displayed by GIS mapping show that the Ethiopian rural highlands (>1500m) contain nearly all cultivated or managed areas. This data coincides with data from the FAO shown in Table 3.2, which places 70-80% of cattle within the Ethiopian highland region, but lower levels of other livestock. It can be inferred that that cattle in this region are tied into the cereal crop production of the Ethiopian highlands. Oxen are widely considered the most important domestic animals in the Ethiopian highlands as nearly all of the traction for cultivation is performed by oxen (Halderman 2004). Pastoralists, in contrast to Ethiopian highland communities, utilize their livestock on a more subsistence basis. Livestock provide their pastoralist owners with considerable protein and their main source of income and asset accumulation. With the least developed infrastructure services, livestock in pastoral areas are more than a necessity – they are pastoralists' way of life.

Trends of Deforestation and Degradation

Because of their unique lifestyle, pastoralists have nearly constant exposure to their outdoor environment, and are sensitive to how that environment changes. Pastoral communities have a detailed knowledge of the environment of the grazing lands. This knowledge is gained through continuous herding, and is supplemented by the knowledge accumulated from historical land use

(Angassa et al., 2008). Community-based knowledge of environmental change can complement ecological methods, and can improve understanding of local conditions. It has been argued that the community-based approach is more practical and relevant to environmental issues and ecological impact than many other sources such as ecological studies (Angassa et al., 2008).

Figure 3.5 illustrates the trend of increases in agricultural area and the decrease in forested areas. While agricultural expansion is not identical to livestock, it is accepted that nearly all traction for cultivation and plowing in Ethiopia are provided by livestock. This makes livestock responsible for not only degradation within the grazing land in pastoral areas, but cropland in the Ethiopian highlands as well. "The need to feed livestock grain and/or crop residues is a driver of expanding crop production in mixed farming systems into lands previously allocated to other uses. This land conversion affects soil, biodiversity, greenhouse gas emissions and water quality" (EPAR 155, pg. 1). FAO data of forest cover showed a consistent decline from 141,000-140,400 hectares lost each year (Figure 3.5 and Appendix). This data reinforces statistics cited in Ellen Winberg's Participatory Forest Management report on Ethiopia (2010). Consistent with other estimates of annual forest loss, the FAO data shows that forest cover in Ethiopia is indeed shrinking. The literature surrounding Ethiopian agriculture contests that agricultural production, and specifically the demand for cropland and grazing land.

Vegetation Impacts and Degradations

The data within the EILS, are supported by a *Journal of Arid Environments* article on the changes in soil nutrients and vegetation structure as a response to grazing in Ethiopia. Heavy grazing leads to excess defoliation of standing biomass and herbaceous vegetation as well as a decline in species diversity and net productivity as grazing increases (Tessema et al., 2011). The conclusion of this report was that using soil quality parameters, heavy grazing in Ethiopia alters herbaceous vegetation composition through an increase in the abundance of annual species with a decline in perennial grasses.

A 2011 study in the *Journal of Environmental Management* on the botanical composition of grasses and soils characteristics in relation to land-use suggested that grazing pressure may be the primary cause of differences in grass layers in Ethiopia.

Moreover, grazing pressure had also an effect on the silt content. The higher sand content is probably caused by increasing run off and soil erosion, triggered by the higher percentage of bare ground and low basal cover, as well as low standing biomass of the herbaceous vegetation. Grazing affects the flux of nutrients in grazing lands through trampling, consumption, excreta deposition and redistribution and export (Tessema et al., 2011).

A 2011 study conducted by the Ethiopian Agricultural Research Organization supports the findings of factors influencing rangeland degradation include increases in encroachment by undesirable

woody plants, expansion of weeds, reduction in herbaceous/woody layers and recurrent droughts. Overgrazing and over-utilization of woody plants have also brought about reductions in the species composition of important fodder plants, reducing the grazing/browsing capacities of the rangelands.

Productivity

An area of livestock production that was reiterated in FAO Working Papers, The Environmental Implications of Livestock Series, and within Interviews was productivity and efficiency per animal. Dirk Hoekstra, Project Manager for ILRI projects in Ethiopia, stated in his interview that the most important goal in the Ethiopian livestock sector was to improve the per-animal environmental impacts by providing a more productive base (the same amount of erosion per cow, but less erosion per kilo of meat or per liter of milk). In order to achieve a greater productivity per animal, the following need to be addressed:

- genetic problems (i.e. low-quality breeding stock, disease);
- fodder availability and fodder quality;
- veterinary services (access and quality); and
- marketing.

Climate Change

Ethiopia is a country with a very diverse and highly variable climate. Historically, there has been a strong link observed between climate variations and the overall performance of the country's economy (Forum for Environment, 2011). Ethiopia has direct and disproportionately high dependence on natural resources and climate sensitive livelihoods coupled with the prevalence of rampant poverty, leaving the country in a highly vulnerable position (Forum for Environment, 2011). Climate change is likely to harm developing countries that generate a major portion of their GDP from climate sensitive sectors such as agriculture. According to the FAO Working Paper 19, Ethiopia derives 30-35% of its total GDP from agriculture (FAO, 2004). Climate change has the potential to have massive implications for Ethiopia's drought prone arid environment, as well as the economy that relies so heavily on that environment.

The broader trends of environmental degradation as a result of livestock production in Sub-Saharan Africa have been explored by the EILS. The greenhouse gas emission from livestock in developing countries (Ethiopia has the largest livestock population in Africa) shown in Figure 3.6 are most directly related to climate change. The relative inefficiency of grazing cattle in developing regions may be partially explained by feed. Pasture-raised livestock may emit from 3 to 3.5 times the amount of methane as compared to intensively raised livestock due to lower digestibility of their feed (Lipson et al., 2011). Also, in a resource-constrained farm system, a large proportion of feed is often spent on minimal maintenance and not on generating products, which makes their resource intake

inefficient (Lipson et al., 2011). These gases contribute to the estimated 18% of global anthropogenic greenhouse gas emissions that livestock are responsible for (Steinfeld et al., 2006).

Climate change affects biodiversity, soil degradation reducing water quality, nitrate and sediment pollution of water. Climate change and variability are key drivers for environmental degradation, though their effects will be most severely felt in the coming decades. Its key effects will be increased dryness and higher temperatures, reductions in primary productivity, land use changes, changing animal disease distributions, land degradation in some cases, changes in species composition (and thereby animal diets and feeding strategies), livestock productivity, incomes and food security (Ayantunde et al., 2011).

Herder Perceptions/Local Voices

Degradations in biological and physical rangeland resources have become serious challenges, and are well understood by the pastoral communities that are most affected. The studies documenting local perceptions of land degradation reinforce and sharpen findings.

By considering herders' knowledge and involving them in the decision-making process for development, a more sustainable use of the local resources and a better future for pastoralists could be promoted (Angassa, 2008). New policy should recognize the importance of reintroducing fire for the management of bush encroachment and be linked to communities' fodder management strategies. In this regard, future management programs for the control of bush encroachment also need to understand the mechanisms of bush encroachment in relation to land use and the rehabilitation and management of bush-invaded rangelands (Angassa, 2008).

Rangeland degradation is less understood by policymakers development planners and researchers, confused with desertification, influenced by biases of western intellectuals. As a result, pastoral perceptions are overlooked, and the production system considered as ecologically unfriendly and unsustainable (Angassa, 2008).

Recommendations

Mitigation strategies for decreasing land degradation as a result of livestock in Ethiopia, informed by the EILS reports:

- Engage in nutrient management strategies that encompass: (1) effective nutrient cycling between plants, soil and animals, (2) improved plant and animal nutrient retention and efficiency, (3) alternative uses of grazing land and (4) multi-use buffers on grazing or cropland periphery.
- Decrease animal morbidity and mortality: Dairy cow mortality across the production cycle in developing countries is estimated at four percent. Unproductive or unusable livestock

represent an investment of feed with low or no output, and producing feed (or grazing of land) is inextricably linked with some degree of land degradation. This recommendation is supported by the ILRI interviews, as productivity increases were cited as the primary goal of the livestock sector.

- Remove grazing from marginal areas and concentrate it in productive areas where ecosystem resilience and degradation resistance is greatest (Lipson et al., 2011).

MoARD needs to work collaboratively with FAO and IGAD and researchers to effectively implement mitigation strategies to help improve livestock production efficiency. Better feed and grazing strategies would allow for more cattle on less land and for that land to be degraded to a lesser extent. Though livestock is only part of the agricultural expansion that causes deforestation, it is a fundamental component inherently linked with crop production.

Carbon sequestration efforts to help reduce the impact of greenhouse gas emissions generated from livestock production. This is an especially appealing policy option if funding is available from international development partners.

In order to effectively enact and monitor any potential livestock policy, there must be a prerequisite of full participation of relevant stakeholders to promote sustainable land and livestock management practices (Forum for Environment, 2011). For livestock policy in Ethiopia, that requires the participation of the following stakeholders:

- Government agencies: ministries (i.e. MoARD), the regional and zonal bureaus, and *woreda* offices and community level development agents;
- research institutes (FAO, IGAD, and ILRI);
- regulatory agencies including the Environmental Protection Authority (EPA);
- NGOs and international development partners; and
- local land users and managers.

Successful livestock policy will require all be involved and invested in some degree with the policy making process and support the proposed measures to improve livestock productivity and reduce the negative externalities associated with livestock production in Ethiopia.

Conclusion

As a country in the developing world with a substantial population growth rate, Ethiopia is struggling to feed itself. Understandably, agricultural expansion in Ethiopia is the government's top priority, according to the Federal Policy and Investment Framework from 2010-2020 documents.

Paramount to Ethiopia's agricultural expansion is the livestock sector, which is estimated to account for 45% of agricultural GDP or more.

Current trends related to expanding agriculture in Ethiopia, such as deforestation and other forms of land degradation are a high level risk to the improvement living standards within the country. There is forest cover loss in Ethiopia due to a variety of factors. Fuel wood demand from increased population pressures and agricultural expansion are among the biggest contributors to forest loss and degradation. Changes in vegetation cover and biodiversity have altered traditional grazing lands which have supported the livestock production system in Ethiopia for thousands of years.

Anthropogenic climate change spurred by livestock generated GHG emissions is a growing threat to further land degradation in Ethiopia. As much of Ethiopia is composed of arid or semi-arid habitats, drastic changes in precipitation and droughts exacerbated by climate change could further disrupt the already fragile agricultural production systems of the country.

Ethiopia is fortunate to have a large body of international organizations aiding in research dedicated to help mitigate issues within agricultural production and food security. The FAO and other related organizations have provided substantial policy recommendations supported by decades of data and research to aid in livestock productivity and efficiency. While Ethiopia is in a precarious position regarding its natural resources and agricultural systems, there are tools and policy options available to help move in the right direction.

Just as crucial as scientific studies is the incorporation of local knowledge and perceptions of environmental degradation. Any future policy surrounding Ethiopian livestock production systems needs to take into account:

- the enormous social and economic value of livestock to rural Ethiopians;
- the fragile and already much degraded rangeland and highland ecosystems;
- the feedback loops that the environmental impacts of livestock create; and
- local knowledge and what Ethiopians perceive to be the most crucial indicators of environmental degradation as it pertains to livestock production.

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Appendices

Appendix 3A

GIS- LCCS & the GlobCover legend

Value	GlobCover legend	LCCS Label	LCCS Entry	
11	Post-flooding or irrigated croplands (or aquatic)	Irrigated tree crops // Irrigated shrub crops // Irrigated herbaceous crops // Post-flooding cultivation of herbaceous crops	A11 Cultivated Terrestrial Areas and Managed Lands	
14	Rainfed croplands	Rainfed shrub crops // Rainfed tree crops // Rainfed herbaceous crops		
20	Mosaic cropland (50-70%) / vegetation (20-50%)	Cultivated and managed terrestrial areas / Natural and semi-natural primarily terrestrial vegetation		
30	Mosaic vegetation (50-70%) / cropland (20-50%)	Natural and semi-natural primarily terrestrial vegetation / Cultivated and managed terrestrial areas		
40	Closed to open (>15%) broadleaved evergreen or semi-deciduous forest (> 5m)	Broadleaved evergreen closed to open trees // Semi-deciduous closed to open trees	A12 Natural and Semi-natural Terrestrial Vegetation	Woody - Trees
50	Closed (>40%) broadleaved deciduous forest (>5m)	Broadleaved deciduous closed to open (100-40%) trees		
60	Open (15-40%) broadleaved deciduous forest/woodland (>5m)	Broadleaved deciduous (40-(20-10)%) woodland		
70	Closed (>40%) needleleaved evergreen forest (>5m)	Needleleaved evergreen closed to open (100-40%) trees		
90	Open (15-40%) needleleaved deciduous or evergreen forest (>5m)	Needleleaved evergreen (40-(20-10)%) woodland // Needleleaved deciduous (40-(20-10)%) woodland		
100	Closed to open (>15%) mixed broadleaved and needleleaved forest (>5m)	Broadleaved closed to open trees / Needleleaved closed to open trees		
110	Mosaic forest or shrubland (50-70%) / grassland (20-50%)	Closed to open trees / Closed to open shrubland (thicket) // Herbaceous closed to open vegetation		
120	Mosaic grassland (50-70%) / forest or shrubland (20-50%)	Closed to open shrubland (thicket) // Herbaceous closed to open vegetation / Closed to open trees		
130	Closed to open (>15%) (broadleaved or needleleaved, evergreen or deciduous) shrubland (<5m)	Broadleaved closed to open shrubland (thicket)		Shrub
140	Closed to open (>15%) herbaceous vegetation (grassland, savannas or lichens/mosses)	Herbaceous closed to very open vegetation // Closed to open lichens/mosses		Herbaceous
150	Sparse (<15%) vegetation	Sparse trees // Herbaceous sparse vegetation // Sparse shrubs		

160	Closed to open (>15%) broadleaved forest regularly flooded (semi-permanently or temporarily) - Fresh or brackish water	Closed to open (100-40%) broadleaved trees on temporarily flooded land, water quality: fresh water // Closed to open (100-40%) broadleaved trees on permanently flooded land, water quality: fresh water	A24 Natural and Seminatural Aquatic Vegetation
170	Closed (>40%) broadleaved forest or shrubland permanently flooded - Saline or brackish water	Closed to open (100-40%) broadleaved trees on permanently flooded land (with daily variations), water quality: saline water // Closed to open (100-40%) broadleaved trees on permanently flooded land (with daily variations), water quality: brackish water // Closed to open (100-40%) semi-deciduous shrubland on permanently flooded land (with daily variations), water quality: saline water // Closed to open (100-40%) semi-deciduous shrubland on permanently flooded land (with daily variations), water quality: brackish water	
180	Closed to open (>15%) grassland or woody vegetation on regularly flooded or waterlogged soil - Fresh, brackish or saline water	Closed to open shrubs // Closed to open herbaceous vegetation	
190	Artificial surfaces and associated areas (Urban areas >50%)	Artificial surfaces and associated areas	**B15 Artificial Surfaces**
200	Bare areas	Bare areas	**B16 Bare Areas**
210	Water bodies	Natural water bodies // Artificial water bodies	**B28 Inland Waterbodies, snow and ice**
220	Permanent snow and ice	Artificial perennial snow // Artificial perennial ice // Perennial snow // Perennial ice	

Appendix 3B

Table 3.B1 Livestock totals by type in Ethiopia, FAOSTAT, 2011.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Cattle	33075300	35383300	40638800	39000000	38749300	40390100	43124600	47570700	49297900	50884000
Goats	8597770	9620890	11000000	12000000	14850600	16364000	18559700	21709400	21798500	21960700
Sheep	10950700	11438200	14321800	16000000	18074700	20733900	23633000	26117300	25017200	25979900
Chickens	28543000	37764000	40930000	38000000	35656000	32222000	34199000	39508000	38049000	38000000

Table 3.B2 Livestock totals, FAOSTAT, 2011.

Total Livestock	Year
81166770	2000
94206390	2001
106890600	2002
105000000	2003
107330600	2004
109710000	2005
119516300	2006
134905400	2007
134162600	2008
136824600	2009

Table 3.B3 Livestock totals as a function of time, FAOSTAT, 2011.

Regression Statistics (Total Livestock by Year)	
Multiple R	0.9637
R Square	0.9287
Adjusted R Square	0.9198
Standard Error	5211268.562
Observations	10

		SS	MS	F	Significance F
Regression	1	2.8E+15	2.8E+15	104.258	7.3E-06
Residual	8	2.2E+14	2.7E+13		
Total	9	3E+15			

	Coefficients	Standard Error	t Stat	P-value
Intercept	-1.163E+10	1.2E+09	-10.112	7.8E-06
Year	5,858,280.24	573742	10.2107	7.3E-06

Appendix 3C

E-mail with ILRI Team Leader- Innovation in livestock systems.

16 November, 2011.

Questions/Talking Points:

As an impoverished nation, what are the most readily available innovations accessible to Ethiopia?

We look at innovation in a much broader sense and as a social process that helps translate knowledge into developmental outcomes. Even if we go by a narrow definition, it is not easy to answer the question. There must be hundreds of technologies, practices, processes and institutional arrangements and policies that could be used in the agricultural sector. It is not a straightforward listing of technologies, as you might be interpreting it. You need to understand that innovation is very context specific and so is the relevance of technologies and knowledge. Ethiopia and Ethiopian farmers (as is the case with almost all developing countries) are not one homogenous entity and one size does not fit all.

The Ethiopian government through the Ministry of Agriculture has stated that increasing agricultural productivity is their top priority. How can innovations in fodder and other areas of livestock production improve productivity? Are productivity improvements likely to improve or worsen the environmental impacts of livestock in Ethiopia?

And if you look at innovation in a narrow sense of technology or practice, do people not adopt technologies/practices which would increase the productivity which is yield or production per unit of input? On the environmental impacts – how I wish life were that simple and so black and white, that we can say productivity improvement simply improves or worsens environmental impact of livestock! All kinds of productivity increases do not have the same effect on environment.

What agricultural investments would be the most worthwhile for a country like Ethiopia to pursue?

Agriculture is a very broad and complex field and it depends on what your objectives are – what do you want to achieve through your investments. Is it economic growth and efficiency; is it broadbased development for poverty alleviation; is it environmental sustainability while achieving economic growth; is it just about protecting environment?? Different objectives demand different strategies for different sections of the populations and hence, different investments!