Country Pasture/Forage Resource Profiles

ETHIOPIA

by

Alemayehu Mengistu
The designations employed and the presentation of material in this information product do not imply the expression of any opinion whatsoever on the part of the Food and Agriculture Organization of the United Nations (FAO) concerning the legal or development status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. The mention of specific companies or products of manufacturers, whether or not these have been patented, does not imply that these have been endorsed or recommended by FAO in preference to others of a similar nature that are not mentioned.

The views expressed in this information product are those of the author(s) and do not necessarily reflect the views of FAO.

All rights reserved. FAO encourages the reproduction and dissemination of material in this information product. Non-commercial uses will be authorized free of charge, upon request. Reproduction for resale or other commercial purposes, including educational purposes, may incur fees. Applications for permission to reproduce or disseminate FAO copyright materials, and all queries concerning rights and licences, should be addressed by e-mail to copyright@fao.org or to the Chief, Publishing Policy and Support Branch, Office of Knowledge Exchange, Research and Extension, FAO, Viale delle Terme di Caracalla, 00153 Rome, Italy.

© FAO 2006
1. INTRODUCTION

The Federal Democratic Republic of Ethiopia (FDRE) is a landlocked country in the horn of Africa, bounded to the north by Eritrea, to the west by Sudan, to the south by Kenya and to the east by Somalia and Djibouti; it lies within the tropics between 3°24’ and 14°53’ N; and 32°42’ and 48°12’ E (see Figure 1). It covers 1 120 000 km$^2$ in nine regional states, one City Council and one City Administration. Smallholder peasants farm 8% (about 10 000 000 ha) of the national land area and about 3 100 000 ha are fallow. The total area of grazing and browse is estimated to be 61 000 000–65 000 000 ha, of which 12% is in mixed farming and the rest in pastoral areas (Alemayehu, 1998a; MoA, 2000). The population was estimated at about 63 000 000, making it the third most populous country in Africa, after Egypt and Nigeria, but according to the World Factbook the July 2006 estimate was 74 777 981 with a growth rate of 2.31%. The male-female ratio is almost one to one. Rural population is 85.3% and the rest is urban (CSA, 1999).

Ethiopia is culturally and biologically diverse, among the four most diverse countries in Africa for endemic vertebrates; 15% of the estimated 7 000 vascular plants are thought to be endemic. Ethiopia has a diverse mix of ethnic and linguistic backgrounds; in fact among the top 25 countries in the world in endemic linguistic diversity. It is has more than 80 ethnic groups, each with its own language, and about 200 dialects, culture and traditions. The four main language groups are: Semitic, Cushitic, Omotic and Nilo-Saharan. One of the most significant areas of Ethiopian culture is its literature, which is represented predominantly by translations from ancient Greek and Hebrew religious texts into the ancient language Ge’ez, modern Amharic and Tigrigna. Ge’ez, one of the most ancient languages in the world, is still used by the Ethiopian Orthodox Church, which has its own unique customs and traditions that have been influenced by Judaism.

The agricultural sector plays a central role in the economic and social life of the nation and is a cornerstone of the economy. About 80–85% of the people are employed in agriculture, especially farming. The sector contributes about 40% of total GDP; livestock and their products account for about 20% of agricultural GDP. Smallholders, the backbone of the sector, cultivate 95% of the cropped area and produce 90–95% of cereals, pulses and oilseeds. Subsistence agriculture is almost entirely rainfed and yields are generally low.

Within agriculture, some 60% of the output is from crops, with livestock and forestry producing 30% and 7%, respectively. Crop production by area is predominantly cereals (84.55%) followed by pulses

![Figure 1. Location map of Ethiopia.](source MoA, 2000)
(11.13%) and others (4.32%). Five crops account for almost all cereal production: maize (15.75%), teff (*Eragrostis tef*) (25.78%), barley (12.29%), sorghum (12.39%) and wheat (10.76%) [CSA, 1995–1999]. However, crops such as pulses e.g. chick pea, beans, peas; oil crops e.g. sunflower, safflower, rape, neug (*Guizotia abyssinica*), groundnut; and root and plantation crops e.g. potato, sweet potato, yam, cassava, ‘enset’ (*Ensete ventricosum*), and sugar cane have great food and industrial value.

Subsistence crop production is traditional and rainfed, with very limited areas of irrigation. Of around 166 000 ha under irrigation some 64 000 ha is small-scale; while the irrigation potential of the country is estimated at around 3 000 000 ha (EPA, 1997). Small-scale traditional irrigation has been practised for decades in the highlands, where small streams are diverted seasonally for limited dry season cropping. Medium- and large-scale schemes are of more recent origin, particularly in the Rift Valley.

Ethiopia’s livestock population (2002) is the largest in Africa, with 30 000 000 cattle; 24 000 000 sheep; 18 000 000 goats; 7 000 000 equines; 1 000 000 camels and 53 000 000 poultry. About 70% of the cattle and sheep and 30% of the goats are in the highlands above 1 500 m. All camels are in the lowlands (Alemayehu, 1998a). [FAO Statistical databases (Table 1) show somewhat different numbers for 2002 and subsequent years]: cattle 40.6 million; sheep 14.3 million; goats 9.6 million; equines 5.7 million; camels 0.48 million; poultry 40.9 million and these differences need to be checked.

Production from cattle has been estimated to be 620 000 tonnes of meat, 244 000 tonnes of milk, 24 000 000 tonnes of manure and 2 400 000 hides annually [FAO Statistical databases show somewhat different numbers for 2002 and these need checking]. Per capita consumption of milk is estimated at 19 litres/year, while meat consumption is about 13.9 kg/year of which beef and veal contribute 64%; sheep, goats, chicken and camels provide the remainder. Skin and hides are known contributors to local industries and 12–16% of the total export market (MoA, 1997; Alemayehu, 1998a).

Official exports averaged 500 000 sheep and goats [FAO statistical databases show much lower totals and these need checking], mainly to the Middle East especially Saudi Arabia. There are unrecorded cross-border exports to Djibouti, Somalia and Kenya. Domestic demand has outstripped supply, resulting in local prices for cattle that are higher than world prices, constituting a major bottleneck to exports.

The current land tenure system, as per the national rural land proclamation No. 89/1994, assures some security through users’ rights. Land has been a common property of nations and nationalities and shall not be subjected to sale or to other means of transfer. The users’ right helped small farmers to own

Table 1. Ethiopia statistics for livestock numbers, meat and milk production and livestock exports and milk imports for the period 1995–2005

<table>
<thead>
<tr>
<th>Year</th>
<th>Cattle nos (.000,000)</th>
<th>Sheep nos (.000,000)</th>
<th>Goat nos (.000,000)</th>
<th>Horse nos (.000,000)</th>
<th>Asses nos (.000,000)</th>
<th>Camel nos (.000)</th>
<th>Beef and veal prod. (.000 mt.)</th>
<th>Sheep meat prod. (.000 mt.)</th>
<th>Goat meat prod. (.000 mt.)</th>
<th>Total milk prod. (.000 mt.)</th>
<th>Cattle exports (head)</th>
<th>Sheep exports (.000 head)</th>
<th>Goat and mutton meat exports (.000 mt.)</th>
<th>Milk equiv. imports (.000 mt.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>31.2</td>
<td>12.0</td>
<td>8.4</td>
<td>1.20</td>
<td>3.20</td>
<td>370</td>
<td>267</td>
<td>36.1</td>
<td>25.0</td>
<td>996.0</td>
<td>0</td>
<td>4.0</td>
<td>0.5</td>
<td>11.8</td>
</tr>
<tr>
<td>1997</td>
<td>32.6</td>
<td>12.5</td>
<td>8.4</td>
<td>1.22</td>
<td>3.15</td>
<td>410</td>
<td>270</td>
<td>36.1</td>
<td>25.0</td>
<td>1 007.4</td>
<td>800</td>
<td>4.0</td>
<td>1.8</td>
<td>11.8</td>
</tr>
<tr>
<td>1998</td>
<td>35.4</td>
<td>13.4</td>
<td>10.5</td>
<td>1.23</td>
<td>3.17</td>
<td>479</td>
<td>274</td>
<td>36.1</td>
<td>36.2</td>
<td>1 019.1</td>
<td>1 218</td>
<td>15.5</td>
<td>2.5</td>
<td>11.8</td>
</tr>
<tr>
<td>1999</td>
<td>35.1</td>
<td>12.2</td>
<td>9.5</td>
<td>1.21</td>
<td>3.10</td>
<td>527</td>
<td>290</td>
<td>36.2</td>
<td>36.0</td>
<td>1 030.4</td>
<td>1 218</td>
<td>15.5</td>
<td>1.9</td>
<td>12.9</td>
</tr>
<tr>
<td>2000</td>
<td>35.1</td>
<td>11.0</td>
<td>8.6</td>
<td>1.14</td>
<td>3.06</td>
<td>262</td>
<td>294</td>
<td>37.8</td>
<td>37.8</td>
<td>1 365.5</td>
<td>549</td>
<td>40.0</td>
<td>1.2</td>
<td>8.3</td>
</tr>
<tr>
<td>2001</td>
<td>35.4</td>
<td>11.4</td>
<td>9.6</td>
<td>1.26</td>
<td>3.41</td>
<td>327</td>
<td>294</td>
<td>47.7</td>
<td>47.7</td>
<td>1 518.1</td>
<td>326</td>
<td>40.0</td>
<td>0.2</td>
<td>3.8</td>
</tr>
<tr>
<td>2002</td>
<td>40.6</td>
<td>14.3</td>
<td>9.6</td>
<td>1.48</td>
<td>3.90</td>
<td>475</td>
<td>304</td>
<td>49.9</td>
<td>49.9</td>
<td>1 676.4</td>
<td>354</td>
<td>15.0</td>
<td>1.1</td>
<td>12.7</td>
</tr>
<tr>
<td>2003</td>
<td>39.0</td>
<td>15.0</td>
<td>9.6</td>
<td>1.45</td>
<td>3.80</td>
<td>470</td>
<td>304</td>
<td>55.1</td>
<td>55.1</td>
<td>1 587.2</td>
<td>2217</td>
<td>16.6</td>
<td>3.6</td>
<td>21.4</td>
</tr>
<tr>
<td>2004</td>
<td>38.1</td>
<td>16.6</td>
<td>9.6</td>
<td>1.45</td>
<td>3.80</td>
<td>468</td>
<td>304</td>
<td>56.6</td>
<td>56.6</td>
<td>1 583.3</td>
<td>2000</td>
<td>17.0</td>
<td>2.1</td>
<td>5.6</td>
</tr>
<tr>
<td>2005</td>
<td>38.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>n.r.</td>
<td>n.r.</td>
<td>n.r.</td>
<td>n.r.</td>
</tr>
</tbody>
</table>

Source: FAOSTAT, 2006; n.r. = no record
cultivated and grazing lands. Pastoralists have communal ownership rights to grazing lands. Periodic redistribution of land among farmers has been a strong disincentive to carry out improvement and/or erosion control measures.

Land holdings are small and often fragmented into many parcels. Farms of less than a hectare comprise more than 26% of agricultural land; almost 60% is in holdings of less than 2 ha and the rest in holdings between 2–2.5 ha. Ethiopia’s population, currently about 63 000 000, is the second largest in sub-Saharan Africa and is growing fast. High livestock numbers and human population exert pressure on land and force farmers to open new cropland at the expense of grazing and forest. Trade in farm products is almost entirely private with minimum involvement of the public sector. There are no legal restrictions and controls on markets, but local authorities have some regulations and charge fees.

Ethiopia, with its extremely variable agro-climatic conditions, has several major ecological systems that support large and very diverse genetic resources. Despite this huge resource, Ethiopia’s latest estimate of real GDP per capita is Birr 1010.08 (USD 118 00 at the exchange rate of June 2003). It is estimated that 60% of the population live below the line of absolute poverty. Average life expectancy is 49 years.

The poor performance of agriculture is reflected in the national annual food deficit. The sector has been beset by natural disasters, in particular periodic severe droughts, so the substantial natural potential of the highlands, their fertile soil and good rainfall and irrigation have not been realized. Lack of modern inputs for the subsistence sector, especially fertilizer, inadequate availability of credit, poor credit recovery and widespread disorder and civil war are the main constraints. These situations have drawn resources from productive use in the agricultural sector.

The major problems have their roots in poor sectorial policies including controls over input and output prices and insecurity of land tenure. In the lowlands the low rainfall produces inadequate, poor-quality pastures; pastoralists mostly keep cattle for prestige so low livestock production is further aggravated by low offtake. Recently, government structural adjustments and trade liberalization policies are being considered, and these could include guidelines for changes in pricing and marketing of several farm products, including livestock. The intention to give incentives to farmers to target their crop/livestock production to market demands and to practise natural resource conservation could sustain the farming sector.

2. SOILS AND TOPOGRAPHY

Major topographic features
Ethiopia has extremely varied topography (FAO, 1984d). The complex geological history that began long ago and continues accentuates the unevenness of the surface; a highland complex of mountains and bisected plateaux characterizes the landscape. According to some estimates about 50% of African mountains, about 371 432 km² above 2 000 m, are in Ethiopia. Altitudes range from 126 m below sea level in the Dalol (Afar) Depression on the northern border, to the highest mountain, Ras Dejen in the Semen Mountains north of Lake Tana rising to 4 620 m. The plateau in the northern half of the country is bisected by the East African Rift Valley, which runs more than 600 km north–northeast of the Kenyan border to the Koka Dam on the Awash River south of Addis Ababa. The rift then descends to the northeast and its lateral escarpments begin to diverge from each other crossing the Afar depression toward the Red Sea coast.

The lowlands, the major grazing land of Ethiopia, form a wide apron surrounding the highland massif and part of the Great Rift Valley. This arid, hot zone, with up to 90 growing days per year, is suited mainly to extensive grazing. It includes the lowest elevation in the country at 126 m below sea level. The lowlands make up nearly 61–65% of the land-mass, and are the major nomadic pastoralist and agro-pastoralist areas. The topographic diversity of the country has resulted in the formation of a multitude of agro-ecological zones and subzones with varied farming systems (see section 3).
Soils

The wide ranges of topographic and climatic factors, parent material and land use have resulted in extreme variability of soils (FAO, 1984e). In different parts of the country, different soil forming factors have taken precedence. According to the Ministry of Agriculture about 19 soil types are identified throughout the country. The big proportion of the country’s landmass is covered by lithosols, nitosols, cambisols and regosols in order of their importance (see Table 2). Complexes of soil forming factors have primarily influenced the distribution of the soil types (MoA, 2000).

The distribution of the main soil types is shown in Figure 2.

There is limited information on the fertility status of the various soils. Research showed that potassium, nitrogen, cation exchange capacity (CEC) and organic matter contents of most Ethiopian highland soils are generally high by international standards (EARO, 1998), whereas their phosphorus content is low to very low. Compared with the African standard most soils in the highlands of Ethiopia are fertile (FAO, 1984c). Contrary to most other African soils, the majority of Ethiopian highlands soils remain relatively fertile at depth. However, most highland soils are deficient in important nutrients and require fertilizer to sustain crop yields. Research has indicated that Ethiopian soils are generally low in available nitrogen and phosphorus and cannot produce high crop yields unless these are supplied.

<table>
<thead>
<tr>
<th>Soil type</th>
<th>Area (km²)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acrisol</td>
<td>55 726.5</td>
<td>5.0</td>
</tr>
<tr>
<td>Cambisol</td>
<td>124 038</td>
<td>11.1</td>
</tr>
<tr>
<td>Chernozems</td>
<td>814</td>
<td>0.07</td>
</tr>
<tr>
<td>Rendzinas</td>
<td>16 348</td>
<td>1.5</td>
</tr>
<tr>
<td>Gleysols</td>
<td>5 273.5</td>
<td>0.47</td>
</tr>
<tr>
<td>Phaeozems</td>
<td>32 551</td>
<td>2.9</td>
</tr>
<tr>
<td>Lithosol (Leptosols)</td>
<td>163 185</td>
<td>14.7</td>
</tr>
<tr>
<td>Fluvisols</td>
<td>88 261.5</td>
<td>7.9</td>
</tr>
<tr>
<td>Luvisols</td>
<td>64 063.5</td>
<td>5.8</td>
</tr>
<tr>
<td>Nitosols</td>
<td>150 089.5</td>
<td>13.5</td>
</tr>
<tr>
<td>Histosols</td>
<td>4 719.5</td>
<td>0.42</td>
</tr>
<tr>
<td>Arenosols</td>
<td>9 024</td>
<td>0.81</td>
</tr>
<tr>
<td>Regosols</td>
<td>133 596</td>
<td>12.0</td>
</tr>
<tr>
<td>Solonetz</td>
<td>495</td>
<td>0.04</td>
</tr>
<tr>
<td>Andosols</td>
<td>13 556</td>
<td>1.2</td>
</tr>
<tr>
<td>Vertisols</td>
<td>116 785</td>
<td>10.5</td>
</tr>
<tr>
<td>Xarosols</td>
<td>53 171</td>
<td>4.8</td>
</tr>
<tr>
<td>Yermosols</td>
<td>34 950</td>
<td>3.1</td>
</tr>
<tr>
<td>Solonchaks</td>
<td>47 217.5</td>
<td>4.2</td>
</tr>
</tbody>
</table>

Figure 2. Main soils and agro-ecological zones
3. CLIMATE AND AGRO-ECOLOGICAL ZONES

Climate
Climatic elements such as precipitation, temperature, humidity, sunshine and wind are affected by geographic location and altitude. Ethiopia, being near the equator and with an extensive altitude range, has a wide range of climatic features suitable for different agricultural production systems. Climatic heterogeneity is a general characteristic of the country.

Temperature and rainfall are the most important climatic factors for agricultural production in Ethiopia. Altitude is a factor that determines the distribution of climatic factors and land suitability; this influences the crops to be grown, rate of crop growth, natural vegetation types and their species diversity. Taking the two extreme altitudes, temperatures range from the mean annual of 34.5 °C in the Danakil Depression, while minimum temperatures fall below zero in the upper reaches of Mt Ras Degen (4 620 m) with a mean of less than 0 °C, where light snowfalls are recorded in most years. Between these extremes are vast areas of plateaus and marginal slopes where mean annual temperatures are between 10° and 20 °C.

According to FAO (1984a) rainfall in Ethiopia is generally correlated with altitude. Middle and higher altitudes (above 1 500 m) receive substantially greater falls than do the lowlands, except the lowlands in the west where rainfall is high. Generally average annual rainfall of areas above 1 500 m exceeds 900 mm. In the lowlands (below 1 500 m) rainfall is erratic and averages below 600 mm. There is strong inter-annual variability of rainfall all over the country. Despite variable rainfall, which makes agricultural planning difficult, a substantial proportion of the country gets enough rain for rainfed crop production (FAO, 1984b). Distribution of rainfall is shown in Figure 3.

In the north of the country the rainfall pattern is mainly bimodal, with the shorter of the seasons around March/April; the second rainy season often begins around June/July. In some areas the two seasons combine into a unimodal pattern; this is commoner in the west and some northern parts of the country where rainfall is generally higher. Between these extremes, in the central highlands, there is a tendency for the two seasons to merge. The lowlands of the east and southeast contrast with the rest of the country by having a bimodal rainfall distribution, and have marginal rainfall for crop production (MoA, 2000; FAO, 1984b).

Temperature and rainfall, in combination with topography and soils, determine moisture availability, which determines vegetation and agricultural productivity. Based on moisture regimes, FAO (1984a) classified 50% of the country as having sufficient moisture for annual crops and another 16% is thought to be reliable for perennial crops.
Vegetation
Natural vegetation is influenced by five biomes: savannah, montane, tropical thickets, wooded steppe and desert biomes (Encyclopedia Britannica, 1996). According to White’s (1983) vegetation classification, the country has four of the regional centres of endemism: Sudanian Regional Centre, Somalia-Maasai Regional Centre, Afromontane Regional Centre and Afroalpine Regional Centre. The natural vegetation can be assigned to eight major types that range from Afroalpine formations through dense high canopy montane forest to savannah, scrubland and desert. A simplified vegetation distribution map is shown in Figure 4.

According to Zirihun Woldu (1999), Ethiopia was once heavily treed with about 34% of its area and 57% of the land above 1500 m covered by dense forests and a further 20% by wooded savannah. Massive deforestation has reduced these figures to 3.6% of the total area and 9% of the land above 1500 m. Widespread deforestation started, particularly in the highlands, at the end of the nineteenth century with the expansion of agriculture. The current deforestation rate is estimated to be 200,000 ha/year with most of the surviving forest in remnant patches in inaccessible and remote areas.

The main Ethiopian plateau is characterized by broad rolling uplands, immense cultivation with good soil. In June–September the landscape is green. In December it is yellow–tan with ripe grain and stubble. In March it is grey–black ploughed fields of traditional subsistence farms.

The grazing lands of Ethiopia are in the arid, semi-arid and subhumid zones that cover around 61–65% of the land mass and have a number of agro-ecological subzones with diverse types of crop and animal production. The arid zone altitude range is from 126 m below sea level to 1,200 m; mean annual rainfall is from 100 to 600 mm and the potential evapotranspiration (PET) is estimated at 1,700–3,000 mm. The mean temperature is above 27 °C. Since rainfall is erratic, crops are irrigated.

The arid zone plains are bushed grassland, except some patches of woodland. The Rift Valley and escarpments are covered by wooded grassland. Crop production is only along rivers (irrigated state farms). Cotton, maize and sorghum are the dominant annual crops, among the perennials are citrus, banana and mango. Stock rearing (goat, sheep, camel and cattle) is the major land use. Dominant trees and shrubs include: Prosopis juliflora, Tamarix aphylla, Calotropis procera, Parkinsonia aculeata, Balamites aegypitiaca, Dodonaea angustifolia, Rumex nervosus, Acacia spp., Combretum molle, Azadirachta indica, Salix subserrata, Carissa edulis, Tamarindus indica and Euclea schimperi. Among wildlife wild-ass, zebra, duiker, lion, leopard and ostrich are known to exist. Nomadic and semi-nomadic pastoralism is the common livestock production system in the arid zones.

The semi-arid zone (400–2,200 m) has mean annual rainfall of 300–800 mm; PET ranges between 1,900 to 2,100 mm, and a growing period of 46–60 days. Hilly areas and stony terrain are under wooded grassland or bush grassland: flat land is under rainfed crops (often mechanized). Extensive grazing is
the major land use and cattle, goats, sheep and donkey are the major stock. Trees include: *Boswellia papyrifera*, *Acacia seyal*, *Acacia senegal*, *Acacia nilotica*, *Ziziphus* spp., *Diospyros mespiliformis* and *Balanites aegyptiaca*. Common wildlife are: reticulated giraffe, Grant’s gazelle, oryx, Burchell’s zebra, waterbuck, elephant, lion, duiker, greater kudu, lesser kudu and buffalo.

The Ethiopian rift system is in the arid–semi-arid zone; the main Rift Valley is a zone of intensive agricultural activity. Increasing and progressive settlement has replaced grazing lands with small to medium farms, some of which are mechanized. Originally the vegetation in the rift floor and escarpments was wooded grassland with *Balanites*, *Combretum* and various species of *Acacia*. Broad-leaved woodland dominated by *Combretum*, *Olea* spp., *Celtis*, *Dodonaea viscosa* and *Euclea* occupies the mid-altitudes of the escarpments. Lake margins and swamps of the Rift Valley are covered by swampy genera of *Typha*, *Phragmites* and *Cyperus*, with *Suaeda monoica* on alkaline soils.

**Agro-ecological zones**

The multitude of agro-ecological zones (AEZs) is traditionally classified into five categories with traditional names assigned to each zone, based on altitude and temperature: Bereha, kola, weinadega, dega and wurch. However, the amount of rainfall and its distribution are also important in classifying common agro-ecological zones (see Table 3).

It is common to associate the traditional zones with elevation and temperature and try to recognize agroclimatic and vegetation zones. Authors have recognized different agroclimatic zones and associated them with the traditional system. Many researchers have classified the vegetation and ecological zones (Zerihun, 1999; MoA, 2000). General characteristic of the different zones are presented in Table 4.

According to MoA (2000) many of the classifications and characterizations are not comprehensive and are discipline oriented. The current AEZ classification (MoA, 2000) is based on the basic ecological elements of climate, physiography, soils, vegetation, farming systems, etc. The intention of better characterization is to suit the country’s diverse but unique natural and cultural diversity. Current AEZs are based on temperature and moisture regimes. Eighteen major AEZs are delineated and named by terms describing the broad moisture and elevation conditions of areas (Box 1). A total of 49 agro-ecological subzones are identified based on

### Table 3. Traditional Ethiopian agro-ecological zones

<table>
<thead>
<tr>
<th>Zone</th>
<th>Altitude (m)</th>
<th>Mean rainfall (mm)</th>
<th>Temperature °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bereha (dry-hot)</td>
<td>500–1 500</td>
<td>&lt;900</td>
<td>&gt;22</td>
</tr>
<tr>
<td>Weinadega (dry- warm)</td>
<td>1 500–2 500</td>
<td>&lt;900</td>
<td>18–20</td>
</tr>
<tr>
<td>Erteb Kola (submoist warm)</td>
<td>500–1 500</td>
<td>900–1 000</td>
<td>18–24</td>
</tr>
<tr>
<td>Weinadega (submoist cool)</td>
<td>1 500–2 500</td>
<td>900–1 000</td>
<td>18–20</td>
</tr>
<tr>
<td>Erteb Weinadega (moist- cool)</td>
<td>1 500–2 500</td>
<td>&gt;1 000</td>
<td>18–20</td>
</tr>
<tr>
<td>Dega (cold)</td>
<td>2 500–3 500</td>
<td>900–1 000</td>
<td>14–18</td>
</tr>
<tr>
<td>Erteb dega (moist cold)</td>
<td>2 500–3 500</td>
<td>&gt;1 000</td>
<td>10–14</td>
</tr>
<tr>
<td>Wurch (very cold or alpine)</td>
<td>&gt;3 500</td>
<td>&gt;1 000</td>
<td>&lt;10</td>
</tr>
</tbody>
</table>

Source: MoA, 2000

Note: The extreme desert (between 500 and 126 metres) area is not traditionally classified

### Box 1

**Current major agro-ecological zones of Ethiopia**

<table>
<thead>
<tr>
<th>No.</th>
<th>Code</th>
<th>Zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>A1</td>
<td>Hot to warm-arid lowland plains</td>
</tr>
<tr>
<td>2.</td>
<td>A2</td>
<td>Tepid to cool arid mid highlands</td>
</tr>
<tr>
<td>3.</td>
<td>SA 1</td>
<td>Hot to warm semi-arid lowlands</td>
</tr>
<tr>
<td>4.</td>
<td>SA 2</td>
<td>Tepid to cool semi-arid highlands</td>
</tr>
<tr>
<td>5.</td>
<td>SA 1</td>
<td>Hot to warm submoist lowlands</td>
</tr>
<tr>
<td>6.</td>
<td>SM 2</td>
<td>Tepid to cool submoist highlands</td>
</tr>
<tr>
<td>7.</td>
<td>SM 3</td>
<td>Cold to very cold submoist subafroalpine</td>
</tr>
<tr>
<td>8.</td>
<td>M1</td>
<td>Hot to warm moist lowlands</td>
</tr>
<tr>
<td>9.</td>
<td>M2</td>
<td>Tepid to cool moist mid highlands</td>
</tr>
<tr>
<td>10.</td>
<td>M3</td>
<td>Cold to very cold subafroalpine to Afroalpine</td>
</tr>
<tr>
<td>11.</td>
<td>SH 1</td>
<td>Hot to warm subhumid lowlands</td>
</tr>
<tr>
<td>12.</td>
<td>SH 2</td>
<td>Tepid to cool subhumid highlands</td>
</tr>
<tr>
<td>13.</td>
<td>H3</td>
<td>Cold to very cold subhumid subafroalpine</td>
</tr>
<tr>
<td>14.</td>
<td>H1</td>
<td>Hot to warm humid lowlands</td>
</tr>
<tr>
<td>15.</td>
<td>H2</td>
<td>Tepid to cool humid highlands</td>
</tr>
<tr>
<td>16.</td>
<td>H3</td>
<td>Cold to very cold humid subafroalpine</td>
</tr>
<tr>
<td>17.</td>
<td>Ph 1</td>
<td>Hot to warm per-humid lowlands</td>
</tr>
<tr>
<td>18.</td>
<td>Ph 2</td>
<td>Tepid to cool per-humid highlands</td>
</tr>
</tbody>
</table>

Source: MoA, 2000
### Table 4. General features of the agro-ecological zones

<table>
<thead>
<tr>
<th>Traditional zone</th>
<th>Altitude (m)</th>
<th>Rainfall (mm)</th>
<th>Soil type</th>
<th>Natural vegetation</th>
<th>Main plant species</th>
<th>Crops</th>
<th>Livestock</th>
</tr>
</thead>
<tbody>
<tr>
<td>High wurch (alpine)</td>
<td>&gt; 3 700</td>
<td>&gt; 1 400</td>
<td>Black, little disturbed</td>
<td>Afroalpine steppe meadow</td>
<td>Mountain grassland (Artemisia, Helichrysum, Lobelia)</td>
<td>None, Frost Limit</td>
<td>Sheep, cattle</td>
</tr>
<tr>
<td>Wet wurch (subalpine)</td>
<td>3 700–3 200</td>
<td>&gt; 1 400</td>
<td>Black, highly degraded</td>
<td>Subalpine</td>
<td>Erica, Hypericum</td>
<td>Barley (2 Crops/Year)</td>
<td>Sheep, cattle donkeys</td>
</tr>
<tr>
<td>Moist wurch (subalpine)</td>
<td>3 700–3 200</td>
<td>1 400–900</td>
<td>Black, degraded</td>
<td>Subalpine</td>
<td>Erica, Hypericum</td>
<td>Barley (1 Crop/Year)</td>
<td>Sheep, goats, cattle, poultry horses, bees</td>
</tr>
<tr>
<td>Wet dega (high land)</td>
<td>3 200–2 300</td>
<td>&gt;1 400</td>
<td>Dark brown clay</td>
<td>Aframontane forest bamboo</td>
<td>Juniperus, Hagenia, Podocarpus, Arundinaria</td>
<td>Barley, Wheat, Neug, Pulses (2 Crops/Year)</td>
<td>Sheep, Cattle, Goats, horses, Bees, Poultry</td>
</tr>
<tr>
<td>Wet woyna dega (mid altitude)</td>
<td>2 300–1 500</td>
<td>&gt; 1 400</td>
<td>Widespread drainage</td>
<td>Acacia, Cordia, Ficus, Arundinaria</td>
<td>Tef, Maize, Enset (In West) Neug, Barley</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moist woyna dega (mid altitude)</td>
<td>2 300–1 500</td>
<td>1 400–900</td>
<td>Red brown drainage</td>
<td>Acacia, Cordia, Ficus</td>
<td>Maize, Sorghum, Tef, Enset, (Rare) Wheat, Neug, Finger, Millet, Barley</td>
<td></td>
<td>Cattle, goats, sheep, horses, mules, donkeys, bees, poultry</td>
</tr>
<tr>
<td>Dry woyna dega (mid altitude)</td>
<td>2 300–1 500</td>
<td>&lt;900</td>
<td>Light brown to yellow</td>
<td>Savannah</td>
<td>Acacia</td>
<td>Wheat, Tef, Maize (Rare)</td>
<td>Cattle, goats, donkeys, bees</td>
</tr>
<tr>
<td>Wet kola (low land)</td>
<td>1 500–500</td>
<td>&gt;1 400</td>
<td>Red clay, oxidised</td>
<td>Milletia, Cyathea, Albizia</td>
<td>Mango, Taro, Sugar, Maize, Coffee, Orange</td>
<td></td>
<td>Cattle, goats, donkeys, bees</td>
</tr>
<tr>
<td>Moist kola (low land)</td>
<td>1 500–500</td>
<td>1 400–900</td>
<td>Yellow silt</td>
<td>Acacia, Erythrina, Cordia, Ficus</td>
<td>Sorghum, Teff (Rare), Neug, Finger, Millet, Groundnuts</td>
<td></td>
<td>Cattle, goats, bees, donkeys, poultry</td>
</tr>
<tr>
<td>Dry kola (low land)</td>
<td>1 500–500</td>
<td>&lt;900</td>
<td>Yellow sand</td>
<td>Acacia spp.</td>
<td>Sorghum (Rare), Teff</td>
<td></td>
<td>Goats, cattle, camels, sheep, donkeys, poultry</td>
</tr>
<tr>
<td>Bereha (low land deserts) Note in the earlier table this unit is over 500 m!</td>
<td>&lt;500</td>
<td>&lt;900</td>
<td>Yellow sand</td>
<td>Acacia-Commiphora bush land</td>
<td>Acacia, Commiphora</td>
<td>Only With Irrigation</td>
<td>Camels, goats</td>
</tr>
</tbody>
</table>

homogeneity in terms of climate, physiography, soils, vegetation, land use, farming system and animal production (See Figure 5).

**Major agricultural enterprises in the different agro-ecological zones**

Ethiopian farmers have long recognized that altitude, climate, water availability, vegetation and other physical and biotic factors are interrelated to agricultural potential and production. The traditional
classification, developed over thousands of years, divides the country into major and minor agro-
ecological groups based primarily on altitude and rainfall. Each zone and subzone is further characterized
by variations in economic activity, population density and other socio-cultural attributes such as cropping
and livestock rearing patterns.

The dominant agricultural enterprises in all agro-ecological zones are small-scale subsistence
farms in the highlands and livestock rearing in the lowlands. Large enterprises (ex state farms) were
government holdings that are being privatized. Current private investments are mainly in the agro-
industrial sector especially on cash-crop and livestock production. Production systems in Ethiopia are as
complex as the agro-ecological zones, and amplified further by the cultural diversity of people. General
description of the major agricultural enterprises, crop–livestock and pastoral production enterprises are
discussed below.

Smallholder crop production
In the higher part of the mountains, the proper Afroalpine zone (‘Wurch’), plants are exposed to intense
radiation, with much greater rise in the temperature of the aerial parts in contrast to their underground
parts; transpiration is higher than the absorption of water by the plant, so, though moisture is not
limiting, plants are mostly adapted to moisture deficiency. The soil is often shallow, even though very
rich in undecomposed organic matter. With the steepness of the terrain and the frequent heavy rains,
the zone is vulnerable to erosion following human activity. In the subafroalpine zone, the lower ‘wurch’
area, (3 200–3 700 m) cropping is limited to barley, with two crops per year sometimes being possible
with rainfall above 1 400 mm/annum; only one crop is possible in areas with 900–1 400 mm. Sheep are
the main livestock but cattle are kept and contribute to farm power. The major agricultural enterprise is
small-scale mixed farming. Population density is relatively lower, but black soil areas are degraded due
to cropping for thousands of years without any protection.

Small- to medium-scale crop–livestock production. The most productive zones are between 3 200 and
1 500 m highland (‘dega’) and lowland (‘Woina dega’). In this agro-ecological zone a wide range of
crops are grown and many species of livestock kept for different ends. Production systems are, in fact, of
a mixed crop plus livestock type with draught power being important. Rainfall is generally not limiting
except in the far north and growing seasons are often very long, with two crops per year in some areas.
Due to high population, farming is dominated by smallholdings. Medium-scale private crop production
is beginning as a result of the recent state farms privatization and the new investment policy. Medium- or
large-scale dairying is found around big towns and cities.

Small- to large-scale livestock production. In many agro-ecological zones at low altitudes 1 500–
500 m (kola-zone) growing seasons are short to very short, so only drought resistant crops can be
grown, unless irrigation is possible. Livestock are important throughout this zone. The poor conditions
for crops and the extensive system of livestock production imply low human population. There is large-
scale ranching, particularly fattening for domestic and export markets; ELFORA Pvt. Ltd. Company (ex.
Livestock/Meat Development Corporation) is one large-scale (commercial) livestock/meat producing
company operating here.

The lowlands are the home of a diverse array of pastoral people who depend on livestock, which
feed on native vegetation, and net productivity is very variable over time and space. The lowlands are
home to 29 ethnic groups, of which more than 90% are pastoralists. Livestock provide subsistence and
employment for more than 10 000 000 people and are a source of meat, milk and fibre for residents of
some two dozen major towns and cities within or adjacent to the lowlands. Subsistence nomadic and
semi-nomadic pastoralists are the major stockholders on the grazing land. Afar, Somali and Borana are
the major pastoral groups in the northeastern, eastern and southern grazing lands. Production systems
and stock management are described in section 4.
4. Ruminant Livestock Production Systems

Livestock genetic resources: With its varied climatic and topographic conditions, its ethnic composition and the size of its national herd, Ethiopia is a major repository of livestock resources and genetic diversity but little has yet been done to describe them other than in superficial terms. “Breeds” are recognized by morphology, or more often by the name of an ethnic group or locality. Much still needs to be done at the genetic level to gain a fuller understanding of the relationships among types, classes, breeds and populations.

Cattle: Most local cattle are zebus; recognized breeds, including Boran, Fogera, Horro, Sheko (Gimira), Abigat (Adal), are indigenous to and synonymous with particular regions. The Fogera and Horro are known as milk producers, the first being reared round Lake Tana in Amhara State and the second in Eastern Welega in the west of Oromiya State. The Boran, renowned as a beef breed well beyond the boundaries of Ethiopia, is also “indigenous” to Kenya and Somalia where its tribal owners claim territory; it is found in the south and east of the country in the Southern Nation Nationalities and Peoples’ Regional State (SNNPRS) and in Somali Regional State. The Nuer breed in the southwest is considered to have tolerance to high tsetse challenge. European breeds, especially Friesian and Jersey, have been imported for many years and crossed with indigenous cattle to improve dairy production.

Sheep: Almost all sheep in Ethiopia are indigenous; several breeds have been identified but are less clearly differentiated than cattle. These have evolved in situ under various, but universally harsh, conditions of health care, feeding and management, and often of climate. Their output is low but is probably capable of being improved if better circumstances are provided. National research institutions and the International Livestock Research Institute (ILRI) have done some preliminary breed characterization. Formal cross-breeding has been confined to the Debre Berhan station of the Ministry of Agriculture (MoA) at about 2 800 m, some 120 km north of Addis Ababa. The main “improver” breeds have been Awassi and Corriedale but little success has been achieved in transferring results to the smallholder sector.

Goats: Until very recently, the situation was very similar to that for sheep; their huge genetic resource was largely unknown in terms of breeds or population composition and there was confusion over terminology. Some early types identified included a short-haired goat in the Danakil Desert, the white and variegated goats of the Hararghe highlands, a Bati goat in Wello valued for its skin, the Arusi goat and other types of the western lowlands. More recently a comprehensive survey of goat populations included physical inspection and handling of more than 14 000 animals. In this study a number of qualitative and quantitative variables were used to characterize goats into four major categories and 14 distinct types; estimates of geographical distribution and population size were also attempted. Further information was gained on production systems, management practices, flock structure and reproductive history.

Sedentary production systems
Ethiopian livestock production systems can be classified into three broad categories:

- subsistence crop related livestock production;
- purely pastoralist production; and
- private commercial or parastatal production.

In the first two systems enterprises are mainly smallholdings, while the last includes medium- to large-scale market-oriented production units. Parastatal and commercial livestock production systems with more intensive animal production are mostly found around peri-urban and urban areas and, to a lesser extent, around the previous farmer’ cooperatives and few private rural areas. Dairying and fattening of oxen and small ruminant are the most popular activities.

Small-scale subsistence production. In this system, where food and cash crop growing is the main agricultural activity, farm size ranges from 0.5–1 ha. Soil fertility maintenance is a major problem. Livestock are for draught, seasonal milk and meat production and a source of food and income. Cattle
are the main stock. Feed resources are natural pasture, crop residues and to lesser extent improved pasture and forages. Milk yield is 1 litre/day, and average land area 0.25 ha per animal.

**Medium-scale intensive dairying and fattening.** Farmers use all or part of their land to grow improved pasture and forage, some buy agro-industrial by-products and use their land for food and cash crops. Manure is used on crops. Milk is the main source of income and farmers use family labour and sometimes hire help for dairying and fattening. Feeds are from improved pasture and forages and purchased concentrates. Milk production is continuous from crossbred animals (Local Zebu crossed with Friesian), ranging from 5–8 litres/day; a crossbred animal occupies 0.5 to 1 ha, on holdings of 1–2 ha. Major inputs include crossbred cows, artificial insemination (AI), credit, veterinary extension and training.

**Peri-urban commercial dairying.** This occurs around cities where demand for milk is high. The main feeds are agroindustrial by-products (concentrates), purchased bush hay, improved pasture and forages and crop residues. Milk, often sold directly to consumers, is the main source of income. High-grade crossbred cows are fed on purchased concentrates and roughages; the enterprise is commercial. Milk production is continuous and yield per crossbred cow ranges from 10 to 15 litres; a cow is held on between 0.25 and 0.5 ha. Inputs include concentrates, roughages, grade stock, AI, credit, extension, training and veterinary services.

**Feeding systems.** Livestock mainly feed on natural pasture, weeds of arable land, fallows and crop residues left after harvest. Bottomlands are set aside for hay to be used for severe dry periods. In the highlands farmers fence small areas of pasture, which are grazed by oxen at the time of ploughing and used to feed young calves. Most stock graze on hilltops, swamps, forest margins, roadsides and stony or unfertile lands.

Fallows and crop residues are grazed in the morning and evening as cattle are taken to and from daytime grazing areas. Small calves that cannot go to distant areas graze fallows and crop residues. Cut-and-carry feeding and dry season feed supplemented with crop residues and agro-industrial products are common in the mid- and high-altitude mixed farming systems.

In high potential areas, dairy farmers grow improved pasture and forages, mainly fed on cut-and-carry, and hay. Dairy associations have started silage making for their milch cows. Farmers involved in small-scale fattening do cut-and-carry and hay (from natural pasture and crop residues) feeding. Residues of local grain by-product and beverages are mixed with salt and given to milking cows, plough oxen and fattening animals. In the lowlands (pastoral areas) livestock graze and browse.

**Integrated crop–livestock production system.** In the mixed production systems, cattle play an important role by supplying draught, while equines are the highland beasts of burden. Small ruminants and poultry are the main source of cash and family consumption. In the higher areas (above 3 000 m) barley and sheep predominate; this system covers parts of North-Wollo; the Eastern Mountains of Gojjam and the Semen Mountains of Gonder.

**Highland annual crop and livestock farming.** The high crop-related livestock production system is found between 1 500 and 3 000 m with an estimated area of 12 500 000 ha. A wide range of cereals, oil crops and food legumes are grown. Cattle are kept for traction and fuel, a small number of sheep and goats provide cash. The system is common in the highlands of Tigray, Wollo, Gonder, Gojjam, Shewa and parts of Wellega. Farms are very small and often fragmented. Due to high population density and expanded cultivation, grazing areas are reduced to lands unsuitable for cropping, or fallsows, waterlogged land and steep slopes. The feed situation in this system is precarious and a challenge to the development of both the resource itself and food grain production.

**Highland perennial crop farming.** Another mixed system found between 1 500 and 3 000 m. This area has intensive crops with cultivation and livestock number per household being higher; it is predominant in Southern Ethiopia, particularly the Chat (Catha edulis) and coffee growing areas of Harerge; and enset (Ensete ventricosum) plantations of Walaita, Sidamo and Gurage. It also touches the coffee-growing area
of Jima and Wellega. Livestock are not important for traction as hoe cultivation is used in the highland perennial crops. Feed in this system is from native pasture and crop residues.

**Pastoral systems**

Pastoralists exploit grazing land in arid and semi-arid areas. Among the most notable pastoralists are the Borana, Somali and the Afars around the southern, eastern and northeastern parts to the country, respectively. The pastoral population is estimated at 12–15 million. They have no permanent home and move with their herds within their traditional territory. Livestock is for subsistence and seasonal milk production. Yield/cow/day is 0.5–1 litre. The average land area per animal is from 5 to 10 ha. Livestock include cattle, sheep, goats and camels. Inputs include veterinary (supply of drugs and vaccines) services, water and road development. These areas sell young bulls to highland farmers (for traction) through exchange for cereals (mainly maize), and also contribute the highest number of animals for export.

The extensive pastoral system. Lowlands below 1 500 m are arid or semi-arid. Here livestock rearing is the mainstay of people, and livestock and livestock products provide subsistence, either directly as milk, milk products, meat and blood, or indirectly in the form of purchased cereals through sales of animals; crop production is limited. This production system is extensive; feed and water supply are achieved through either constant or partial herd mobility. A strong traditional built-in system or social laws maintain a sustainable resource management, and govern this system. The pastoral lands of Ethiopia are in the border regions and the ethnic groups are often transboundary. For example, Afar pastoralists are found in Eritrea, Ethiopia and Djibouti; Somali pastoralists of eastern Ethiopia are also found in Djibouti, Somalia and Kenya, and the Borana homeland is between Ethiopia and Kenya.

A nomadic pastoral system denotes an economy that derives the bulk of its food supply from livestock, using a great variety of herding practices, on natural pasture, provided that the system involves some degree of mobility. A transhumant system allows members of the communities to practise some crop production in settlement areas. Despite the attempt to integrate farming with livestock around settlement areas, crop production has remained opportunistic. Pastoralism presupposes a sustainable balance between the human and animal population and the pasture. Such a balance is precarious and rarely occurs, even with highly developed indigenous social organization (Alemayehu Mengistu, 1998b).

Pastoralists maintain livestock under environmental conditions of risk and uncertainty using traditional strategies. Such strategies in Ethiopian nomadic and semi-nomadic systems include:

- maintenance of multispecies herds and supplementation of pastoral resources with agricultural by-products;
- herd splitting into spatially appropriate units, to minimize the effect of localized overgrazing and overbrowsing, disease and other environmental vagaries;
- establishment and maintenance of social systems for sharing, borrowing, giving and conservation of common resources. There are well-defined and extensive institutional frameworks for sharing resources and rehabilitation of members’ herds after a time of crisis;
- maintenance of as large a herd as possible to minimize the chance of losing all and maximize the chance of having some left over after hazards;
- reduction of the number of household members during bad times, such as severe drought and disease outbreaks, by sending away all able-bodied people not required in the system to work in agropastoral and other agricultural areas.

**Extensive grazing systems.** Pastoralists’ resource management is traditional; regulations are decided by the local community. Traditional rulers decide from collective choices taken after discussion. The rules structure individual and collective choice, which allows the herders to manage grazing as common property. Decisions are made with a high level of community involvement of men, aimed at efficient and sustainable use of resources.

An important point to mention is their tree management rules. Trees have high value to pastoral people; they are used as fodder, as food in periods of stress and are important for shade. Pastoral people are not allowed to lop trees when there are other fodder sources available, i.e. grass and bush. They do not cut trees for firewood but gather dead wood, mainly along perennial and seasonal watercourses.
Pastoralists are never allowed, and do not cut fruit trees. Selected men decide tree management rules and a man from each extended household is elected to uphold them; he gives permission to lop trees when needed.

Pastoralists know how to select the most appropriate seasonal grazing and browsing areas, and protect areas that have already been grazed. They make decisions on a daily basis in their use of natural resources. They do not have complex rules of management and are only concerned with the key resource, such as dry season feed areas. Pasture production on such land is low. This makes the pastoralists survival subject to unpredictable natural events that force them to make agreement with highland people to have seasonal access to each other’s grazing and natural resources. The widely known rules of grazing management are:

• conservation of grazing area
• moving animals during dry periods
• demarcation of grazing lands and settlement areas
• division of the herd into mobile grazing (‘fora’) and home-based grazing (‘warra’) groups
• migration of family members
• bush control (burning), and.
• shifting cultivation

Pastoralists experience strong seasonal fluctuation in feed availability and quality; an increasingly popular practice is the establishment of a special enclosure where standing hay is surrounded by thorn-bush fence (Alemayehu Mengistu, 1998b) to be used in the dry season for feeding immature stock and lactating cows. In addition to feed storage, this allows optimal plant growth and helps the pasture condition as it allows both seed setting and plant re-growth. During good rain years, feed is most available in the rainy season and then markedly declines in the dry season, so haymaking is also becoming common, especially by partially settled pastoralists. Crop residues are also used in areas where there is cultivation.

Herd management. Livestock breeding is based on local knowledge; breeding stock are selected for their ability to survive periods of temperature fluctuation, shortage of water and fodder, insects and diseases. Selection also considers the amount of milk the animal supplies as well as fertility. Lowland pastoralists practise herd splitting, which is dividing their herd into separate units depending on type, age, sex and productivity. Small ruminants are usually separated from cattle and camels based on different requirements of fodder, water and salt. Camels are herded separately mainly because of their lower watering frequency, and long movement in search of fodder. Herders cooperate to look after split herds of related families.

Herd composition is designed to meet the people’s needs and fit the environment. The arid zone natural resource base is highly unpredictable and the people keep multispecies herds. The system displays a relatively high degree of flexibility. Cattle and sheep that were part of the Afar herds are now decreasing in numbers, as more emphasis is put on goats and camels. Camels were rare in the Borana, but now are becoming very common.

Most of these people are nomadic; a few have settled permanently (mostly transhumance) and mixed with other ethnic groups and practise crop and commercial activities. Camel and goat keeping is the main economic activity of the pastoralists. They have also been engaged in salt-caravans for many centuries.

Cattle management. Pastoralists manage cattle in a traditional pastoral fashion. According to Coppock (1994) suckling calves are kept apart from their dams except when used to stimulate letdown of milk at two milkings per day. Bulls commonly run with cows all year so mating is uncontrolled and periodicity is influenced by seasonal fluctuation in nutrition. Cows are milked early in the morning and evening. Most grazing time is spent on grasses with less time spent on browse.

Where water and grazing resources permit, pastoralists lead a semi-settled existence. The household may remain sedentary throughout the year, or a succession of years, and family residences in a given well area may last for generations. Cattle are herded either as home-based groups or mobile grazing groups. Herd splitting is done depending on the condition of the resource base, availability of labour, sex and age class of animals and whether cows are in milk or dry.
As described by many researchers, the primary purpose of the herd splitting system is to distribute animals away from the home-encampment area during times of restricted forage and water availability. Strong and less productive animals are sent with mobile grazing herds managed by older boys and young men. At the other extreme home herds are composed of milking cows and some weak or sick yearlings that return to the encampment each night. These are kept within closer grazing orbits whose radii vary depending whether the day is used for grazing or both for grazing and watering.

The mobile grazing herd is composed of dry cows and males of diverse ages and ranges widely. The composition and size of home based herds and mobile grazing herds are dynamic across seasons, type of average rainfall, and dry or drought years. Larger and more heterogeneous home-based herds may characterize years of high rainfall, while the inverse holds for mobile grazing herds. Both home-based and mobile grazing herds are watered once every three to four days during dry periods. This is considered as a management adaptation to minimize labour required to raise water from deep wells.

Sheep and goat management. Pastoralists keep large flocks of sheep and goats for subsistence, income, breeding, restoring wealth and social prestige. At a subsistence level, sheep and goats are kept for occasional slaughter for meat. At present goats are kept for their milk, especially as food for children in the dry season and for adults in times of shortage. Sheep are rarely milked. She and goats are sold regularly in exchange for small commodities and food items. Offtake is mainly males while the females are reserved for breeding. The nomadic pastoralists’ sheep and goats are to a high degree drought resistant and well adapted to arid range with bush vegetation. Goats are highly productive and used for milk, butter and meat. Milk is very important for the nourishment of children. Skins are used for storing butter, for churning milk, as water buckets, for storage of cereals and for sale.

The age of goats first kidding is 8 to 12 months; kidding interval is six months. Four- to five-day-old male goats (kids) are often given to guests as a gift. Some newborn male goats are slaughtered after a few days to increase the amount of milk for the family use. In the dry season all the new kids are slaughtered, because of fodder scarcity and female goats would be unable to survive with suckling kids.

Some male sheep and goats are kept for reproduction and meat. At the age of four–five years, male sheep and goats are castrated for fattening, and called ‘sanga’. They grow fast and provide good meat; sangas command a high price in local and export markets and are preferred for ritual occasions: holydays, when a woman has given birth and during circumcision ceremonies.

Camel raising. Camels are of great interest for the lowland peoples and pastoralists in particular; they are uniquely adapted to the lowlands of Ethiopia, and contribute significantly to the food security of pastoral households. Their most important use is for milk and transport of household and commercial goods. The protein, fat and vitamin-C content of camel milk is vital for pastoralists living in an environment that lacks vegetables. Pastoralists use camels for travel and/or commercial operations; domestic uses include carrying grain, commodities from market, large quantities of drinking water from wells both for people and calves in dry season; they are also used for ploughing. Most pastoral campments have at least one camel.

The preferred number of female or male camels that are kept in different localities varies according to the proximity of the communities to commercial goods sources such as saltlans. The market value of a camel varies from USD 175 to USD 200. Members of different communities exchange males for transport and females for milk.

Ethiopian camels are raised under traditional management; there are few studies on camel husbandry. The multiple changes in the dryland environment and lack of veterinary services, coupled with low reproductive performance, make camel raising difficult; it is a slower process than goat raising. Sexual maturity is at four to five years and they usually calve once per year.

Calf management is considered very important by herders and is given considerable attention at home or in the encampment. Herders consider sufficient milk supply, provision of water during dry seasons, good pasture and good control of parasites as important calf care measures. Herd splitting to reduce competition for forage, water and salt between herds optimizes resource utilization; this strategy also guarantees continuous supply of milk for the families, and meets both the needs of calves and the family. The management of the herd attempts to ensure a sustainable flow of benefits from camels to
households. With limited resources, investment on calf rearing by the pastoralists is relatively intensive. Keeping them in confinement during most of their first year is important in helping calves to thermo-regulate in what can often be a cold and windy environment during rainy periods; this also minimizes risk of predation. Women regularly remove manure from calf pens and attend to health problems such as removal of ticks using kerosene and traditional remedies to heal wounds and internal ailments.

The importance of salt for camels is well known among herders; camels depend on salty plants, salty soils and salt supplements. Herders recognize camels with salt-deficiency symptoms and give them supplements. There is an occasional salt supplementation where salty plants and soils are scarce.

Traditional breeding management considers the selection of breed female and male camels, and controlled breeding. All females are considered fit for breeding; selection is mostly focused on bulls. Once a bull is selected for breeding he is used as long as possible, but sires are kept only for five to seven years in a herd. Letting a selected bull browse with breeding females controls breeding and all unwanted bulls either browse separately or are castrated.

Limitations of ruminant livestock production
It has been long recognized that the limitations to increasing livestock development (increasing production and productivity) in Ethiopia are multidimensional. Constraints can be grouped into socio-economic and technical limitations. Socio-economic constraints encompass policy issues, land tenure, institutional, marketing and budgetary. Major technical constraints include health, feed and genetics.

Socio-economic limitations

• **Policy issues:** Livestock is an integral part of the national resource. There is need for an environment policy for natural resources to be used in ways that allow sustained production in the long term. Livestock and natural resources management are influenced by many aspects of government policy, ranging from economic and social to political. The major policy issues that are relevant to ruminant livestock production are:
  • absence of livestock policy;
  • pricing policy;
  • community organization and participation.

• **Land tenure:** In the past discriminatory allocation of land in favour of collective farming and absence of users’ right discouraged small farmers from investing in livestock and land improvement. Equally important was the discouragement of private land acquisition, which prevented the emergence of private livestock farming. At present land scarcity in the highlands is leading to development of the less productive alpine and semi-arid pastoral areas.

• **Infrastructure:** Ethiopia has one of the lowest densities of roads of any country, thus forcing cattle in almost all cases to trek long distances. Marketing of live animals and meat is constrained by inadequate infrastructure and transport facilities. When stock are trekked, the absence of stock routes, resting areas, watering and feed points results in substantial weight losses before they reach consumption or market areas. Also, inadequate input distribution systems and credit facilities contribute to the poor performance of the livestock sector. Lack of educational infrastructure for training and extension is another important issue that needs to be addressed.

• **Services:** As important as the infrastructure is agricultural services. Inadequate services and livestock technology packages emanating from the weak link between extension and research, absence of beneficiary participatory planning and agricultural training to the changing needs of the country are some of the major institutional constraints.

• **Finance:** Insufficient recurrent expenditure in government services has been a critical constraint. Inadequate staff transport, fuel, repairs and maintenance, vehicles retained beyond their economic life, frequent shortages of drugs, vaccines and semen are some of the problems.

• **Marketing:** The marketing process in general follows a three-tier system with primary, intermediate and terminal markets through which marketable animal and animal products pass from producers to small traders and on to large traders and/or butchers. However, most producers sell their stock and livestock products at local markets directly to consumers or small traders at relatively low prices. The marketing information available to producers is unreliable and inadequate.
Without exception markets are open places in villages and towns. Distance from the market, poor trekking routes and lack of holding grounds create unfavourable conditions for producers forcing them to sell their stock at low prices. Marketing of livestock is not determined on the basis of their weight and quality, but by direct tiresome bargaining between buyers and the sellers. Due to these unfavourable marketing systems and the discouraging price on the producers’ side they are not encouraged to improve the quality and the offtake of their animals.

Technical limitations
Ethiopia’s livestock productivity is below the African average. Total herd offtake is estimated at 7% annually for beef and at 33–36% for sheep and goats, with corresponding carcass weight of 100–110 kg and 8–10 kg respectively. Cows do not reach maturity until 4 years of age, calve every second year, and produce only 1.5 to 2 litres of milk daily over a 150–180-day lactation. As a result per capita consumption of meat and milk is low. Poor health, feed shortage and low genetic potential are the main constraints to increased livestock productivity in the country (ILCA, 1991 and MoA- NLDP, 1998).

• **Pests and diseases:** Animal disease is a major constraint limiting the production of indigenous stock, by restricting the introduction of more productive animals, new technology and constraining the country from entering the high-priced export market. There are epidemics of infectious diseases with high rates of mortality, which could be controlled by vaccination; there are also parasitic, and vector-borne diseases. Trypanosomiasis and internal parasites are very severe, for which effective, easily administered inexpensive control or treatments have not yet been developed. Thus, livestock diseases on their own and interacting with nutritional and productivity problems cause high mortality, morbidity and restrict production in potentially productive areas.

• **Feed quantity and quality:** To feed the increasing human population by continuous cereal growing, available grazing is on the decline. Feed shortages and nutrient deficiencies become more acute in the dry season both in the highlands and lowlands. Studies have indicated that there is a deficit of about 12 300 000 tonnes of dry matter in Ethiopia. For various reasons, crop residues and agro-industrial by-products are not adequately utilized. Cultivation of forage is not widely adopted and commercial feed production is not developed.

• **Livestock breeds:** The genotype of Ethiopian livestock has evolved largely through natural selection influenced by environmental factors. This has made the stock better able to withstand feed and water shortages, disease challenges and harsh climates, but the capacity for high levels of production has remained limited. The non-market-oriented subsistence animal production is incompatible with the farming system of most agro-ecological zones. Crossbreeding and breed substitutions have been done for a more rapid increase in milk production in high potential areas. However, their applicability in the low potential areas, where the ability to survive is the major concern, needs more detailed studies. There are some important indigenous breeds of livestock with remarkable features; the lowland breed of cattle (e.g. Boran) and sheep (e.g. Somali black headed) are often regarded as superior in terms of size, durability, productivity and/or consumer preferences. However there are few detailed studies on these and other indigenous breeds.

• **Recurrent drought and war:** Recurrent drought and the previous prolonged civil war hampered programmes and projects. Infrastructure was destroyed; lives and properties lost due to war and government changes. The inability to strengthen the already existing production is another important limitation that needs to be addressed. Over the decades following the 1974 revolution, the country’s economy grew slowly at a rate of about 2.5% per year. Growth in the economy as a whole was clearly dependent upon the performance of the agricultural sector, which accounts for 40% or more of the GDP. The drought of 1983/84 followed by the more severe drought of 1984/85 caused a massive decline in agricultural output and a dip in the economy as a whole. The subsequent recovery was interrupted by the droughts of 1987/88 and 2002/3. As the economy of the country is based on agriculture, its weak performance has had a direct impact on other sectors. The overall economic slow-down compounded by war and drought resulted in frequent declines in GDP. The GDP drop in 1991/1992 was 5%; however there was a sharp increase to 12.3% in 1992/93. In 1993/94, the rate of growth was a more typical 1.7%. The huge drop was due mainly to drought. In subsequent years annual growth of GDP was 4.9% and 7.6% respectively. This was attained
due to the prevalence of well-timed and good rainfall accompanied by favourable agricultural and economic policies. The inflation rate in 1992/93 was 10%; 1993/94: 12%; 1994/95: 13.4% and in 1995/96: 0.9%

- **Bush encroachment:** Current land tenure does not allow control over community grazing land. Mismanagement coupled with disregard of indigenous knowledge makes bush encroachment one of the major problems in many pastoral areas. Introduction of invasive species without a sound knowledge of the plant and the recipient environment has created great rangeland problems in many lowlands of the country. In the dry southern savannahs, where for centuries episodic climatic events and the use of fire regulated vegetation dynamics, the natural balance between grasses and trees has shifted and bush cover has become a major threat to pastoral grazing management. On 40% of the grazing lands of southern Ethiopia, bush cover exceeds 40% (Coppock, 1994). *Acacia drepanolobium*, *A. brevispica* and other *Acacia* spp. are the dominant encroachers of southern Ethiopia, but the introduced *Prosopis juliflora* is the most frequent plant mentioned as an invader in eastern rangelands.

**Opportunities for intensification of ruminant livestock production**

A possible development opportunity is based on domestic demand for both livestock products and draught power in the face of a growing population that will remain agrarian for a long time to come. Growth of the rural population is high by sub-Saharan African standards and the demand for livestock products will increase. The possibility also exists for the country to regain its place in the export trade, particularly in Gulf and Middle East countries where its stock, especially sheep and cattle, have preference and established demand.

Despite the poor performance of livestock in the past, the country’s livestock, biodiversity and land resource base retain the capacity for improvement. The very large livestock population, highly adapted to the diverse agro-conditions of the country, will be the basis for an increased supply of animal products and work input that is crucial for the upkeep of a sustainable agriculture. Improvements in the excessive wastage due to disease, malnutrition, reproductive inefficiency, marketing and price structure will immensely improve performance.

Improvement of the genetic potential of indigenous ruminant livestock particularly for the dairy industry is an area where private and smallholder interests should be growing, though feed will remain a major constraint. Semi-intensive and backyard poultry are likely to develop on a modest scale because of increasing prices for milk and meat. Improvement of feed quantity and quality is another opportunity; there is great potential of improving both the quantity and quality of pasture and forage. The Ethiopian Agricultural Research Organization (EARO) has developed feeding systems and addressed researchable areas with regard to feed and nutrition to make sound livestock production possible. MoA recently initiated work to improve feed quality and quantity through various programmes aimed at:

- improvement and management of natural pasture;
- improvement of crop residue quality and use;
- development of improved pasture and forage; and
- production and distribution of pasture and forage seed.

Although there is no reliable and comprehensive information, MoA reported that more than 100 000 ha of degraded grazing land has been rehabilitated, in four years, through a well-coordinated grassland improvement programme. However, efforts up to now are insignificant compared with the total area of degraded land, and the effort needs to be continued and strengthened further.

Improving feed supply is possible if backyard forage production, undersowing, oversowing and growing improved pasture and forages are widely adopted. Production of forage seed by contracting smallholders has shown potential as a way of improving seed supply. As crop farming become more intensive, crop residues would become a major feed source; another area is improving the quality of crop residues and efficient utilization of by-products.

For the lowland pastoral areas there are various opportunities for improvement of grazing management. These include:

- encouraging the establishment of a regular monitoring network that is gender-sensitive in order to study and observe pasture conditions and trends;
- encouraging the implementation of regular monitoring of productivity and management problems for livestock and grazing land;
- recognizing and strengthening the traditional knowledge of the pastoralists, both men and women, and forms of grazing management practices by:
- encouraging and strengthening the traditional rules of grazing management, demarcation of settlement areas and herd mobility;
- strengthening the traditionally widespread practice of feed conservation in the form of ‘Kalo’ (traditional hay);
- encouraging fodder banks through hay and other forms of feed conservation;
- investigating and encouraging selection and supplementation with leguminous trees like Acacia and other forage legumes for dry season feeding;
- setting up a regulated scheme for using fire to control bush and improve animal production and health through reducing tick infestations and improving forage quality. This requires policy development and community participation;
- making a detailed analysis of pasture deterioration to ascertain its extent; and
- investigating more appropriate grazing management systems.

Other opportunities can be sought in disease prevention and control. Even though there is no epidemiological data on most livestock diseases and disease reporting is below the required levels, successful control and eradication of rinderpest is an indication of the proper design and implementation potential of the country. If support to similar programmes of priority diseases is given the associated economic loss will be minimized and improved access to potential export markets may be possible.

5. THE PASTURE RESOURCE

Livestock feed resources in Ethiopia are mainly natural grazing and browse, crop residues, improved pasture, forage crops and agro-industrial by-products. As described in section 4, feeding systems include communal or private natural grazing and browsing, cut-and-carry feeding, hay and crop residues. At present, stock are fed almost entirely on natural pasture and crop residues. Grazing is on permanent grazing areas, fallow land and cropland after harvest. Forage availability and quality are not favourable year round and hence gains made in the wet season are totally or partially lost in the dry season. Table 5 shows the feed resource balance of the country.

At present, around dairy and fattening areas there is insignificant production of improved pasture and forages. The contribution of agro-industrial by-products is also minimal and restricted to some urban and peri-urban farms (dairying, poultry and fattening). In the past two decades, considerable efforts have been made to test the adaptability of pasture and forage crops to different agroecological zones; several useful forages have been selected for different zones. The medium- and large-scale private enterprises could benefit from those findings.

Natural pastures

Many researchers and development workers agreed that natural pasture comprises the largest feed resource, but estimates of the contribution of this feed resource vary greatly. Alemayehu (1998a) estimated that 80–85% of all feed comes from natural pasture while some estimates indicate the natural pasture provides 88–90%. This is because the quantity and quality of native pasture varies with altitude, rainfall, soil and cropping intensity. Currently, with the rapid increase of human population and increasing demand for food, grazing lands are steadily shrinking by being converted to arable lands, and are restricted to areas that have little value or farming potential such as hilltops, swampy areas, roadsides and other marginal land. This is particularly evident in the mixed-farming highlands and mid-altitudes.

Grasslands are generally in regions of moderate precipitation, between 250 and 750 mm. Grasses in different parts of the country vary according to the altitude. Most grasses are used as forage and grasslands are usually for grazing, but also provide tall and strong grass for thatch.
Table 5. Estimated feed availability to livestock in Ethiopia

<table>
<thead>
<tr>
<th>Feed resources</th>
<th>Highland</th>
<th>Lowland</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Area ('000 ha)</td>
<td>Availability</td>
<td>Area ('000 ha)</td>
</tr>
<tr>
<td></td>
<td>Tonne DM/ha</td>
<td>Total DM ('000 tonnes)</td>
<td>Conversion FU/kg DM</td>
</tr>
<tr>
<td>Native pasture (a)</td>
<td>22 300</td>
<td>33450.0</td>
<td>0.75</td>
</tr>
<tr>
<td>Crop residues (b)</td>
<td>5 423</td>
<td>6 930.7</td>
<td>0.45</td>
</tr>
<tr>
<td>Cereals</td>
<td>4 688</td>
<td>6 563.2</td>
<td>0.45</td>
</tr>
<tr>
<td>Pulses</td>
<td>735</td>
<td>367.5</td>
<td>0.50</td>
</tr>
<tr>
<td>Stubble grazing</td>
<td>4 688</td>
<td>1 875.2</td>
<td>0.50</td>
</tr>
<tr>
<td>Industrial by-products (c)</td>
<td>-</td>
<td>-</td>
<td>196.0</td>
</tr>
<tr>
<td>Total</td>
<td>37 834</td>
<td>49 384.6</td>
<td>0.50</td>
</tr>
</tbody>
</table>

(a) Area of the natural pasture was from GOE/IUCN (1990)
(b) Area under annual cropping from annual reports, 1979–1989, CSA (1989)
(c) Agricultural industrial by-products (Oil cake, Cotton seed, Bran Molasses) from three years (1987/88–1989/90) average (CSA, 1990). Average yield (tonnes DM/ha) and conversion factors to feed unit were from MoA (1984).
The grassland region of Ethiopia accounts for some 30.5% of the area of the country and is most extensive in the western, southern and southeastern semi-arid lowlands. On the more humid side, open grassland and grassland with some trees are common; grasses may cover as much as 90% of the area. In the drier parts, patches of bush are common and the proportion of grass is reduced to about 70%. Incense and honey harvesting are common.

Natural pastures provide more than 90% of the livestock feed in lowlands, with a wide range of grasses, legumes and other herbs.

**Area and productivity:** Recent information on the area and productivity of natural pasture is scarce because of the expensive (in terms of time and money) nature of data collection. Previous estimates of areas and productivity are very variable. The total grazing and browsing land was estimated to be 61–65 million ha (Alemayehu, 1998a), but is changing due to increasing population and cropping. Productivity estimates also vary, probably due to variation in time and ecological change, rainfall, soil type and cropping intensity.

The previous estimate of natural pasture yield for the lowlands was one tonne DM/ha, while for the highland and mid-altitude on freely drained soils it was 3 tonnes DM/ha and, on seasonally waterlogged fertile areas, yields were about 4–6 tonnes DM/ha (Alemayehu, 1998a). MoA (1984) estimate was 1.5 and 0.56 tonnes DM/ha for the highland and lowland respectively. Another yield estimate for different highland zones (MoA, 1989) was as follows:

- For high potential cereal/livestock zones (HPC/LZ) of savannah grassland and humid temperate pasture: 2 and 2.5 tonnes ha/year respectively.
- For both low potential/cereal livestock zone (LPC/LZ) and for high potential perennial/livestock zone (HPP/LZ) pasture (savannah grassland): 1.5 and 2 tonnes DM/ha/year respectively.

**Species composition.** Natural grasslands constitute the main highland pastures. Besides grasses, they contain 28 *Trifolium* species out of which eight are endemic (Kahurananga, 1986). The highlands have been divided into different altitude zones for the description of the grassland vegetation designated by the characteristics of the plants (Alemayehu, 1985; Kahurananga, 1986). The proportion of legumes tends to increase with increasing altitude; particularly above 2 200 m, there is a wide range of annual and perennial *Trifolium* spp. and annual *Medicago* spp. At lower altitudes native legumes are less abundant and commonly have a climbing or sprawling habit with a large variation in their range and density in wet bottomlands. This appears to be only partly due to edaphic differences. In the lowlands browse and shrubs are dominant plants.

**Areas above 3 000 m**
The commonest grasses are species of *Poa, Festuca, Agrostis* and, to a lesser extent, *Andropogon*. In wetter areas sedges occur including the genera *Carex, Eleocharis,* and *Mariscus*. Of perennial legumes, the most important are the deep-rooted *Trifolium burchellianum* (var. *oblungum* and subsp. *johnstonii*) and *Trifolium acaule*, which reach to over 4 000 m. *Trifolium tembense* is the most significant, but occurs only in the lower range. The shrubs *Erica arborea* and *Hypericum revolutum* are common.

**Areas from 2 000 to 3 000 m**
The commonest grasses are species of *Andropogon, Cynodon* and *Pennisetum*. Other common ones are species of *Setaria, Themeda, Erargrostis, Sporobolus, Brachiaria, Paspalum, Phalaris, Chrysopogon* and *Festuca aurindinacea*. Productivity may be extremely high during the later part of the wet season, but there is little growth after early October. Legumes are prolific in this zone; the commonest perennials are *Trifolium semipilosum*, and other frequently occurring ones are: *Trifolium burchellianum* subsp. *johnstonii*, *Trifolium polystachyum* and *Lotus* spp. *Trifolium rupepellianum*, *Trifolium decorum*, *Trifolium steudneri*, *Trifolium quartinianum* and *Vigna* sp. are the most widespread annuals. In very wet bottomlands sedges are common. Of the legumes, *Trifolium tembense* is prolific. Arable land left fallow has a dense weed cover initially, but with heavy grazing it is colonized by grasses, including *Digitaria scalarum, Cynodon dactylon* and *Phalaris paradoxa*. With longer fallow *Cynodon dactylon* and *Pennisetum* spp. become more common, *Trifolium semipilosum* and *Trifolium burchellianum* are also found in such areas. Of the browse species *Erythrina* is common.
Areas from 1 500 to 2 000 m
This zone is characterized by tall grasses and a higher proportion of climbing-sprawling legumes, especially in less intensively settled areas. The commonest grasses are Chloris pychnothrix, Cenchrus ciliaris, Hyparrhenia spp., Setaria spachelata, Paspalum spp., Cynodon dactylon, Pennisetum plicatum, Eleusine flacccifolia, Ergrostis spp., Cymbopogon and Andropogon spp. Perennial legumes include Neonotonia wightii, Indigofera spp., Desmodium spp., Rhynchosia spp., Vigna spp. that grow down to about 1 500 m in the wetter western areas and commonly to 1 800 m in central areas. Stylosanthes fruticosa is found in scattered sites, mainly below 1 800 m, and may be common in degraded areas where few other species thrive. Of the annuals, Trifolium steudneri, Trifolium rupepellianum and Medicago polymorpha are quite frequent above 1 700 m. Of the browse species, Albizia is common and Sesbania is prolific on wet lake margins.

Areas between 1 500 and 500 m
These areas, which include the Rift valley, are covered with Acacia woodland. Today much of the Acacia has been removed as the urban demand for charcoal has increased. Heavy grazing and low-productivity farming have followed the cutting of trees. Common grasses include Chloris pychnothrix, Hyparrhenia anthistirioides, Setaria acromelaena, Aristida kenynensis, Cynodon dactylon, Panicum atrosanguineum, Microchloa kunthii, Hyparrhenia dreggeana, Cenchrus ciliaris, Heteropogon sp., Pennisetum spp. and Bothriochloa insculpta. Of the legumes Neonotonia wightii and the less valuable Indigofera spicata are common. Browse species are dominated by Acacia etbaica, Acacia nilotica subsp. leiocarpa, Acacia tortilis, Acacia seyal var. seyal, Euclea schimperi, Grewia tembensis, G. bicolor, Balanites spp., Cadaba farinosa and Capparis tomentosa.

Conditions and trends of grazing lands
In the highlands plant growth is slow due to low temperature. The high stocking density and intensity of cultivation is out of proportion to the carrying capacity. In the lowlands, the short growing season suits only fast maturing plants; limited rainfall and recurrent drought, shrub invasion and overgrazing are major features of lowland grasslands. Overgrazing and seasonal feed shortage are evident in the country. Many studies have indicated that the grazing lands (except protected areas) of the country are in poor to very poor condition and will deteriorate further unless there is immediate action.

Water sources and management
Since the pastoral areas are arid or semi-arid, water resources are crucial. Water is perhaps the most fundamental feature that has shaped pastoral societies. Surface water traditionally has been scarce in the grazing lands of Ethiopia in general and border grazing land in particular. Here, the discussion is mainly focused on the Borana wells, which are the focal point of their social organization and rituals.

Water for livestock and people is traditionally obtained from ephemeral ponds, perennial springs and rivers, seasonal streams and wells (Alemayehu, 1998b). Water supply in the Borana plateau is dominated by deep wells, which are less common in other areas. The different groups of Borana prefer to move animals to distant water sources in dry periods rather than invest a large effort in digging permanent wells. The Boran mostly use ponds in the rainy season and wells in dry periods. Ponds are easily accessed but are only available for short periods. Wells, however, are unusually permanent water sources but require a large input of labour to lift the water to the surface.

Borana wells can broadly be grouped into shallow (‘adadi’) and deep (‘tula’). Wells are usually in groups of four to twenty. Adadi wells consist of a wide shaft dug into alluvium and can be up to 10 m deep. The tula and crater (found in the bottom of volcanic craters) wells, however, are usually much deeper and require massive excavation with shafts commonly sunk into rock. Adadi wells can be dug at any time and can be an opportune source of water. Tula and crater wells, in contrast, are old. It is often contended that another ethnic group dug them, possibly more than 500 years ago; if the Borana inherited the wells, they have had to adjust their original social system. At least until recently, new well excavation has not been reported. The ‘tula’ wells comprise the most reliable source of water. They reportedly have similar discharge of water during dry and drought years and when watersheds receive lower than average rainfall.

Tula wells are impressive feats of engineering. Animals and people enter the site by travelling down along a narrow ramp flanked by high earthen walls. Entry is regulated by a herder at the gate of a large
storage basin, several metres above, which is a system of clay water troughs that water up to several dozen cattle or other stock at a time. A chain of 5 to 20 people stand on lashed wooden platforms, or rocky protrusions, and pass water from the well with leather buckets (2–5 litre capacity). The whole water management task is physically intense and lifting begins early in the morning. The drinking area for animals is a large flat platform, some 5 to 10 m below the ground and watering and exit of stock is orderly, supervised by a herder.

**Pasture and forage crops**

Over the past two decades several forages have been tested in different ecological zones, and considerable efforts have been made to test the adaptability of different species of pasture and forage crops under varying agro-ecological conditions. As a result, quite a number of useful forages have been selected for different zones. Improved pasture and forages have been grown and used in government ranches, state farms, farmers’ demonstration plots and dairy and fattening areas. Forage crops are commonly grown for feeding dairy cattle with oats and vetch mixtures, Fodder beet, Elephant grass mixed with Siratro and Desmodiums, Rhodes/lucerne mixture, Phalaris/Trifolium mixture, hedgerows of Sesbania, Leucaena and tree-lucerne being the most common. In suitable areas, yields of oat–vetch mixtures are commonly 8–12 tonnes dry matter/ha. Yields of improved pasture and forage grasses and legumes range from 6–8 tonnes and 3–5 tonnes dry matter/ha respectively; and for tree legumes 10–12 tonnes dry matter/ha. Due to land scarcity and crop-dominated farming there has been limited spontaneous introduction of improved pasture and forages. During the Fourth Livestock Development Project, different strategies and species for pasture and forage development were selected (Alemayehu, 2002). These strategies and forages have been promoted widely into the crop–livestock system, traditional grazing areas, and around homesteads, within soil and water conservation structures and under plantation crops and forestry. Details of new species, usage, improved management, their integration in the farming system and local seed production are discussed below.

**Crop residues**

In the highlands and mid-altitude, various food crop residues – cereals (teff, barley, wheat, maize, sorghum and millet) – pulse crop residues (fava beans, chickpeas, haricot beans, field peas, lentils), oil crop residues and reject vegetables are providing a considerable quantity of dry season feed supply in most farming areas of the country. Currently, with the rapid increase of human population and expansion of arable land and with the steady decrease in grazing land, the use of crop residues is increasing. On average crop residues provide 10 to 15% of total feed intake. The same report suggested that in some localities under special crop–livestock production systems, the intake could increase up to 50% (MoA, 1997, Alemayehu, 1998a). The availability of crop residues is closely related to the farming system, the type of crops produced and intensity of cultivation. In integrated crop–livestock systems the potential of using crop residues, as livestock feed is greatest.

**Agro-industrial by-products**

Agro-industrial by-products produced in Ethiopia include by-products from flour milling, sugar factory, abattoir and brewery by-products. These products are mainly used for dairy and fattening animals. Some earlier production estimates of the major agro-industrial by-products are shown in Table 6.

**Limitation of pasture and forage resources**

- **Feed quality and quantity**: Natural grazing is the major source of livestock feed, and in the lowlands livestock production is almost totally dependent on it. However, grazing lands do not fulfill the nutritional requirements of animals particularly in the dry season, due to poor management and their inherent low productivity and poor

<table>
<thead>
<tr>
<th>Table 6. Agro-industrial by-products</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>By-products</strong></td>
</tr>
<tr>
<td>Sugar cane</td>
</tr>
<tr>
<td>Molasses</td>
</tr>
<tr>
<td>Filter press cake</td>
</tr>
<tr>
<td>Bagasse</td>
</tr>
<tr>
<td>Milling by-products</td>
</tr>
<tr>
<td>Oil seed mills</td>
</tr>
<tr>
<td>Sisal waste</td>
</tr>
<tr>
<td>Brewery grains</td>
</tr>
<tr>
<td>Grain screenings</td>
</tr>
<tr>
<td>Sweet potato tops</td>
</tr>
<tr>
<td>Banana waste</td>
</tr>
</tbody>
</table>

Source: MoA, 1984

quality. In the highlands, with the rapid increase of human population and high demand for food, pastures are steadily being converted to farmlands. Marginal lands unsuitable for cultivation such as waterlogged, flooded soils and steep lands are left for grazing and their productivity is very low. Another population associated problem is environmental degradation due to deforestation and overgrazing, which have substantially reduced soil fertility and further reduced productivity.

- **Ecological deterioration**: Gradual encroachment of cultivation into grazing lands is common in both highlands and mid-altitude areas. Many meadows in the flood plains have been converted into croplands. Due to vegetation clearance many steep areas have become vulnerable to wind and water erosion. Important browse that was dry season forage has been wiped out to supply urban fuel and construction wood. Natural grazing land is deteriorating rapidly due to lack of attention and its carrying capacity is declining due to high stocking, especially in pastoral areas. Pastoralism is becoming less and less possible and a riskier business. Since the ecosystem is very fragile, the abuse and mismanagement of resources have created severe problems for people in grazing lands; indigenous people who are adapted to live in the dry lands are facing an ecological crisis.

- **Overgrazing**: Grazing and browsing animals overstock natural pastures; areas near water points are generally the most affected and grazing lands are dominated by unpalatable plants. In many pastoral areas, since the number of stock has socio-cultural value, it has a synergistic effect with the diminishing grazing lands. Soils are under risk of degradation with reduced infiltration, low permeability and a reduction in the water-holding capacity. The result is a decrease in the ability of the soil to support plant production.

- **Land tenure/change of ownership**: In Ethiopia grazing land ownership is thought to be communal, where ethnic groups used to manage grazing lands. However, the federal or regional state can allow private investment in pastoral areas. Besides the loss of grazing land, investment may prevent free movement of pastoralists and initiate urbanization. If the nomadic pastoralists’ sustainable way of life changes to sedentary farming, the tragedy of the commons will become real unless some adjustment is made.

- **Border conflict**: Most extensive grazing lands are limited by ethnic boundaries and are often in border areas. There is conflict between tribes within the country and sometimes with neighbouring countries. This has a profound effect on border grazing land.

- **Drought**: One of the most unfortunate characters of Ethiopia’s climate is great variability of rainfall from year to year. Ethiopia is known for recurrent drought and famine. Drought is particularly common in the pastoral area where rainfall is erratic and unreliable. Nomadic pastoralists have adapted to live with the situation but other factors (listed here) have made them vulnerable to famine.

- **Weed and bush encroachment**: As a result of overgrazing many natural grazing lands are invaded by unpalatable weeds and woody plants. In pastoral areas misunderstanding of the traditional knowledge has lead to restriction of management with fire. Fire is a natural component of tropical ecosystems; its absence has created bush encroachment.

- **Soil fertility**: The annual food and livestock feed deficit of the country is attributed directly to soil erosion and nutrient export. About half of the highlands are vulnerable to water erosion and the remainder has been cultivated without conservation measures for thousands of years.

- **Lack of seed and planting materials**: The absence of quantity and quality seed and seedling production limits the vast expansion of improved pasture and forage development (especially around the dairy farming and fattening areas).
6. OPPORTUNITIES FOR IMPROVEMENT OF FODDER RESOURCES

Pasture and forage genetic resources

Biological resources are fundamental to human well-being: in agriculture, livestock, export earning, economic output and for their ecological services and functions. Ethiopia has an immense ecological diversity and a huge wealth of biological resources. The complex topography coupled with environmental heterogeneity offers suitable environments for a wide range of life forms.

- **Pasture species:** Since Ethiopia is known to be the centre of origin and diversity for a number of domesticated crops, it is also known to be the centre of diversity for pasture and forage species. There are several centres of origin of the cultivated grasses (such as *Chloris* spp., *Panicum* spp., *Setaria* spp. etc.). For the tropical species the main centre is Eastern Africa, from where many promising species and varieties have been selected. In Ethiopia, the large numbers of indigenous grass species and the very great variation within the species make the country a rich potential source of new and better tropical pasture grasses. Until now there are a total of 736 grass species from 181 genera that are documented in Ethiopia, of which 164 species from 68 genera are reported to be important (medium to high level) for pasture and forage purpose.

- **Herbaceous legumes:** Ethiopia is a centre of diversity for herbaceous legumes such as the genera *Trifolium*, *Vigna*, *Lablab*, *Neonotonia*, and others. There are a total of 358 herbaceous forage legume species from 42 general documented in Ethiopia. Reports indicate that about 58 species from 31 genera are potentially important for pasture and forage. Currently 2 076 accessions from 140 species and 35 genera are systematically collected and conserved.

- **Browse trees/shrubs:** Browse trees or shrubs are important animal feed in Ethiopia especially in the arid, semi-arid and mountain zones, where large numbers of the country’s livestock are found. They provide protein, vitamins and mineral elements, which are lacking in grasslands pastures during the dry and/or cold season and serve as standing feed reserves to be built up, so that herds are able to survive critical periods of rainfall shortage. In Ethiopia there are 179 browse species from 51 genera, which is not exhaustive, of which 51 species from 31 genera are recorded as promising browse species. Currently 185 accessions from 41 species and 18 genera are systematically collected and conserved by ILRI (IBCR/E 2001).

Biodiversity conservation. Conservation and use of grass germplasm has made a significant contribution to the economic development of Ethiopia through the national pasture and forage research programme. The International Livestock Research Institute ILRI (ex. ILCA) has done much to fill the gap by collecting grasses from different parts of Ethiopia and by acquiring access to world collections of forage grass germplasm. Currently over 371 accessions of grasses from 77 species and 37 genera, 2 076 accession of legumes from 140 species and 35 genera and 185 accession of browse from 41 species 18 genera are collected and conserved. In recent years the Forage and Pasture Genetic Resource Conservation and Research Department was established under the Institute of Biodiversity Conservation and Research/Ethiopia (IBCR/E) to carry out the conservation of pasture and forage genetic resources.

Pasture rehabilitation

Because of Ethiopia’s diverse climate, there are a number of valuable wild grasses and legumes and browse plants. The highland are rich in pasture species, especially legumes. Herbaceous legumes tend to increase with increasing altitude. There is a wide diversity of annual and perennial *Trifolium* species and annual *Medicago* in the highlands, particularly above 2 000 m. At lower altitudes annual legumes are less abundant, but there are a number of browse species adapted to the dry conditions.

Despite the fact that research on natural improvement is minimal, most trial results are positive. To improve the vegetation composition and the nutritional value of degraded pastures, research on oversowing with legumes and grasses has indicated that vetches (*Vicia dasycarpa* and *V. atropurpurea*) and local clovers (*Trifolium* sp.) were successful in the highlands. In mid-altitudes the perennial *Desmodium uncinatum* has shown superior establishment with Rhodes grass (*Chloris gayana*) and
Siratro (*Macroptilium atropurpureum*). Research and development testing over the last two decades identified promising forages that are suitable for pasture rehabilitation in a wide range of agro-ecological zones (see Table 7).

**Weed control.** Weeds are major problems in both perennial and annual pasture and forage crops; unless they are controlled productivity will be low. In Ethiopia weed control by herbicides, machine mowing and topping and hand weeding have been tried; hand weeding is the best method. Since family and hired labour is plentiful and cheap there is an opportunity to use it for weed control, so there is a considerable opportunity to foster the development of improved pasture and forage crops on a large scale without a major problem of weed infestation.

**Sown pastures and forages**

Climate and land availability provide a good opportunity for forage production. In Ethiopia most improved tropical species can be grown in the lowlands (1 500–2 000 m) and temperate species grow from above 2 100 m up to 3 000 m (Alemayehu, 2002). Introduced improved forage yield is higher than the naturally occurring swards and has higher nutritional value. In addition the length of the productive season is longer for cultivated pastures than for native pastures, which provides an opportunity for dairy and fattening production to develop and use pasture and forage on a large scale.

Greater use of leguminous fodder trees and shrubs assists in increasing soil fertility, controlling soil erosion and providing firewood and timber. These legumes are well adapted to the current edaphic and grazing condition, they can be readily integrated into farming systems, they retain their feeding value

### Table 7. Recommended improved pasture and forage strategies and species

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Low altitude (500–2 000 m)</th>
<th>Medium altitude (2 000–2 400 m)</th>
<th>High altitude (&gt;2 400 m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Backyard forage</td>
<td>Leucaena leucocephala, Sesbania sesban, Cajanus cajan, Chloris gayana, Setaria spp., Panicum maximum, Pennisetum purpureum, Desmodium uncinatum, Medicago sativa</td>
<td>Chamaecytisus palmins, Medicago sativa, Sesbania sesban, Cajanus cajan, Phalaris aquatica, Pennisetum purpureum, Vicia dasycaarpa</td>
<td>Chamaecytisus palmins, Phalaris aquatica, Vicia dasycaarpa, Avena sativa, Medicago sativa,</td>
</tr>
<tr>
<td>2. Undersowing</td>
<td>Lablab purpureus, Vigna unguiculata, Macroptilium atropurpureum, Desmodium uncinatum, Stylosanthes fruticosa, Vicia dasycaarpa, Cassia spp.</td>
<td>Vicia dasycaarpa, Macroptilium atropurpureum, Desmodium uncinatum</td>
<td>Vicia dasycaarpa, Macroptilium atropurpureum, Desmodium uncinatum</td>
</tr>
<tr>
<td>3. Forage strip</td>
<td>Leucaena leucocephala, Sesbania sesban, Cajanus cajan, Panicum maximum, Setaria sphacelata</td>
<td>Chamaecytisus palmins, Sesbania sesban, Cajanus cajan, Desmodium uncinatum, Macrotlyoma axillare, Phalaris aquatica, Vicia dasycaarpa, Stelaria sphacelata, Macroptilium atropurpureum, Stylosanthes fruticosa, Desmodium uncinatum</td>
<td>Chamaecytisus palmins, Vicia dasycaarpa, Phalaris aquatica, Stylosanthes fruticosa, Desmodium uncinatum</td>
</tr>
<tr>
<td>4. Oversowing</td>
<td>Stylosanthes fruticosa, Macroptilium atropurpureum, Cassia spp., Desmodium uncinatum</td>
<td>Chamaecytisus palmins, Sesbania sesban, Macroptilium atropurpureum, Stylosanthes fruticosa, Macroptilium atropurpureum</td>
<td>Phalaris aquatica, Vicia dasycaarpa, Medicago sativa, Avena sativa</td>
</tr>
<tr>
<td>5. Livestock exclusion areas</td>
<td>Cenchrus ciliaris, Leucaena leucocephala, Sesbania sesban, Macroptilium atropurpureum, Stylosanthes fruticosa, Macroptiloma axillare, Desmodium uncinatum, Paspalum plicatum</td>
<td>Chamaecytisus palmins, Sesbania sesban, Macroptilium atropurpureum, Stylosanthes fruticosa, Macroptilium atropurpureum</td>
<td>Chamaecytisus palmins, Phalaris aquatica, Vicia dasycaarpa, Medicago sativa, Avena sativa</td>
</tr>
<tr>
<td>6. Conventional pasture and forage</td>
<td>Stylosanthes fruticosa, Macroptilium atropurpureum, Desmodium uncinatum, Chloris gayana, Panicum maximum, Setaria sphacelata</td>
<td>Phalaris aquatica, Setaria sphacelata, Desmodium uncinatum, Vicia dasycaarpa</td>
<td>Medicago sativa, Vicia dasycaarpa, Phalaris aquatica, Dactylis glomerata, Avena sativa</td>
</tr>
</tbody>
</table>

Source: Alemayehu Mengistu (2001)

Note: The forage strategies and species have been introduced and developed in the different farming systems. Thus: a) sowing stock exclusion degraded grazing areas as a conservation measure (900 ha); b) oversowing with grass or legume seed by broadcasting on communal pasture and on road sides (911 000 ha); c) establishing forage strips and alley strips (18 600 ha); d) backyard forage production by providing an array of multipurpose tree (10 million seedlings) and forage legumes and grasses; e) under-sowing, particularly with annual legumes in maize and sorghum fields (17 500 ha); and f) sowing of pastures with perennial trees (82 ha) have been established and covered. The strategies are found to be very cost effective (low input and out put management) easily accepted by farmers and provide best opportunity to integrate them in crop/livestock/forestry farming systems.
into the dry season and show great success in the higher potential areas of the country. The best adapted strategies and promising plants currently recommended for major zones are listed in Table 7.

Pasture establishment is relatively difficult in the highlands compared to the humid, warmer and lower areas, because of the soil and climate. In the wet season waterlogging, relatively low soil temperature and reduced long and short radiation limit the establishment and subsequent growth of pasture in the highland. In these areas, for the best environmental condition for seed and seedling establishment and growth, perennial pasture is usually sown during the short rains (March and April) but annual forages are usually sown in June (IAR, 1983).

Conventional methods of establishing pasture are tedious and labour demanding, especially in the highlands; better ways are the low-cost methods such as backyard, undersowing and oversowing, which are more attractive to farmers. These strategies provide farmers with proper use of their land for cultivation of crop/pasture and forage/trees, where products can be used for food, feed and firewood respectively. Some perennial grasses can be planted vegetatively; Festuca arundinacea, Phalaris arundinacea and Setaria sphacelata are well adapted to waterlogged conditions and easily established by root splits. There is also considerable opportunity for the use of fodder tree-legumes in agroforestry. Woody legumes provide: a fodder hedge planted around the backyard, firewood, wood for construction of houses and farm equipment, wind breaks, for ceremonial purposes and for stabilizing bunds and gullies. The current promotion of fodder trees-legumes in the national agro-forestry system is a good opportunity for extension of a forage programme within farming systems; and contributes to environmental protection and natural resource management and even to food security.

Integration of pasture and forage into farming systems
One of the best opportunities for highland farmers to use land efficiently will be through the introduction of pasture and forages in the farming system. In trials in the highlands on wheat and barley undersown with lucerne, annual clovers, tall fescue, perennial rye grass, Setaria and Phalaris, the sowing of both cereals and forages was at the same time. All undersown forages established successfully except lucerne and there was no significant reduction of cereal yield. The establishment of forages was much better under wheat than under barley (IAR, 1983). Since falling corn is common in the highlands, undersowing cereals with forages could significantly relieve the feed problems of the area.

At research sites in the mid-altitude area, maize was undersown with Desmodium, phasey bean, Chloris (Rhodes grass), Panicum and Cenchrus after the first weeding. Almost all forages established, and there was no maize yield reduction (IAR, 1983). There is a good opportunity for integration of pasture and forage crops in the existing farming system.

As a result of these findings, in Ethiopia heavy emphasis is put on the use of forage legumes in cropping systems (through undersowing, improvement of fallows and establishment of tree legumes hedges) to partly address the major problems of long-term sustainability of crop production. Extensive use of tree legumes in a number of strategies (Table 7) can have an effect, in the long term, on firewood supplies, including the release of dung that would otherwise have been burnt. The increased forage supply and improved use of forage (dairy and fattening system) will provide another opportunity for generating dung.

There is a wide opportunity for the use of forage pulse crops to be incorporated in the farming system; adapted and recommended crops are: cowpea, pigeon pea and Phaseolus acutifolius. These can be used for food and feed especially during the dry season.

Pasture and forage seed production
Many of the temperate and tropical pasture and forage crops that have been tested and grown in Ethiopia have no problem of flowering and setting seed. This provides a good opportunity for the country to establish local seed production in the existing farming system. The current local pasture and forage seed production systems adopted in the country are:

- Farmer contract seed production system: involves the production of annual and perennials under contract with individual farmers and/or farmer’s cooperatives
- Seed production on ranches: this is mostly for perennial legumes and grass seed
- Seed production on specialized plots: this is undertaken in a few areas by some governmental and non-governmental organizations
• Opportunistic seed production: involves the collection of seed from developed opportunistic pasture/forage sites.

Under these systems over 200 000 tonnes of forage seed were produced from 1988 to 2002. Of the seeds produced, vetch, lablab, cowpea, Axillaris, Siratro, Stylos, Desmodium, oats, Rhodes, Panicum, tree-lucerne, Leucaena and Sesbania are dominant. Large local seed production is under way using farmers’ contracts (Alemayehu, 2001).

Irrigation
The irrigation potential of the country is high; the potential area for irrigation is estimated to be about 3 000 000 ha. Small-scale traditional irrigation has been practised for decades throughout the highlands; small streams are seasonally diverted for limited dry season cropping. This is a good opportunity to grow off-season pasture and forage crops. Medium- and large-scale schemes are of much more recent origin, mostly in the Rift Valley for cash crops. There is some irrigated forage in the Rift Valley growing lucerne/Rhodes mixture for commercial fattening and dairy farming. The potential for irrigated forage is untapped and still there is a great opportunity for producing seasonal and long-term irrigated pasture and forages.

Better grazing land resource management
At every point of resource management, community knowledge and participation, from the beginning to the end, thorough evaluation and monitoring is vital. Ethiopia’s farming people have traditional laws that govern the community, adopted for thousands years. The presence of traditional community rules provides an opportunity in the management of the grazing and other land resources. Current government policies encourage peoples’ participation and community participation from project conception through planning and implementation to monitoring and evaluation undertaken on the decisions of the resource users and managers.

On top of these, protection and penalizing of illegal acts against management of grassland resources, the community exercise their own acceptable by-laws. This provides the best opportunity for correct management of grazing land resources. Based on these, a number of recommended management rules are developed to assist grazing land problems and management. These rules are based on community by-laws.

Recommended rules for grazing land management in Ethiopia
• Respect, promote and encourage the traditional sustainable natural grazing land resource use by the local community.
• Promote the means to zero grazing and controlled grazing and encourage people to see their animals in economic terms (market value) rather than social prestige.
• Encourage the cut-and-carry system of feeding, forage development around homesteads crop farms and hillsides.
• Promote agro-forestry, which also increases firewood, construction material, implements and crafts and forage production.
• Increase animal production through the best utilization of pasture and forages. Integrate soil and water conservation enclosure with sustainable forage production.
• Mobilize indigenous and scientific knowledge into different localities through networks.

In addition to their role in animal feed, pasture and forages in Ethiopia can make a significant contribution to sustainable uses, like watershed management, soil erosion control, soil fertility maintenance, in general to natural resources management and thus to national food security.
7. RESEARCH AND DEVELOPMENT ORGANIZATIONS AND PERSONNEL

Key institutions
Ministry of Agriculture (MoA)
Responsibility for livestock development activities in Ethiopia rests on the Animal and Fisheries Resources Development Main Department (AFRDM) of the MoA. The major activities include the following services:
- Animal breeding and feed resources development
- Animal health services
- Livestock and livestock products marketing
- Fisheries resources development
- Laboratory services

Livestock development programmes include ranches and multiplication centres that produce cross-bred heifers, improved rams, improved cockerels and pullets and pasture and forage seed. The National Artificial Insemination Centre (NAIC) established in 1981 at Kality, produces semen and provides insemination services to dairy owners in different regions of the country.

Teaching institutions
The Alemaya University of Agriculture (AUA); Faculty of Veterinary Medicine, Addis Ababa University (AAU); and agricultural colleges are responsible for teaching and carrying out research required for the national needs. Existing and future regular programmes in some agricultural higher learning institutions:

Alemaya University
PhD: Plant Pathology, Plant Breeding, Animal Nutrition; Soil Science; Agronomy/Crop Physiology
PhD. (Proposed): Animal Breeding/Genetics; Agricultural Economics; Soil and Water Engineering
M.Sc.: Animal Breeding; Animal Production; Soil Science; Plant Breeding; Agronomy; Crop Protection; horticulture; Agricultural Economics; Agricultural Food Marketing; Soil and Water Conservation Engineering; Post-harvest Technology; Agricultural Extension
M.Sc.: Proposed Range Management; Animal Nutrition
DVM: Veterinary Medicine
B.Sc.: Animal Science; Plant Science; Agricultural Economics, Agricultural Engineering; Agricultural Extension;
B.Sc. (Proposed): Food Science and Post-Harvest Technology; Land Resource Management

Debub University
B.Sc.: Agricultural Engineering; Animal and Range Science; Rural Development and Family Science; Plant production and Dryland Farming
Diploma: General Agriculture; Agricultural Engineering; Rural Development and Family Science
M.Sc.: (Proposed) Animal nutrition; Animal Breeding; Animal Science; Range Land Management; Agronomy; Applied Plant Breeding; Crop Protection; Soil Science

Faculty of Veterinary Medicine, Addis Ababa University
M.Sc.: Tropical Veterinary Epidemiology; Tropical Veterinary Medicine
DVM: Veterinary Medicine
Diploma: Animal Health

Ethiopian Agricultural Research Organization (EARO)
The ex Institute of Agriculture Research (IAR) has the mandate to conduct national research programmes in the fields of livestock, forage and pasture, soil fertility studies, crop production and protection and others. Livestock research at EARO is divided into the following divisions:
- Department of Animal of Sciences, main thrust being cattle, sheep and goats;
• Pasture and Forage Crops Department deals with pasture and forage crop research;
• Animal Health (Veterinary Section) Division.

Institute of Biodiversity Conservation and Research (IBCR)
In recent years the Forage and Pasture Genetic Resource Conservation and Research Department under
the Institute of Biodiversity Conservation and Research Ethiopia (IBCR/E) carries out conservation of
forage genetic resources. The department has three main tasks: to evaluate the resource base of pasture and
forage (grass, herbaceous legumes, and browse) in the country; to assess the present state of germplasm
collections of forage with regard to their representation, adequacy, evaluation and documentation, based
on information available from ILRI; to establish priorities for collection and conservation of pasture and
forage germplasm. The major duties of the programme are conservation of forage germplasm in IBCR/E
gene banks and repatriating duplicates of germplasm collected from Ethiopia.

Social Rehabilitation and Development Fund (SRDF)
The task of settling or giving relief aid to war or drought-displaced victims is a crucial social
responsibility. A common relief or immediate action strategy for rehabilitating such victims is to restock
the destitute, mainly with livestock, but also with other items familiar to the farmers. Donations from
philanthropic organizations for the purchase of inputs such as distribution of cattle, improved bulls,
draught oxen, sheep, beehives, chickens, pasture and forage seed and veterinary services are among the
items channelled through the SRDF office to the victims.

Current research and development priorities
Considering the available information on pasture and forage research and development in Ethiopia, the
following themes are considered research and development priorities. Research activities are focusing
on:
• Conservation and research on pasture and forage genetic resources
• Natural pasture improvement
• Screening of drought tolerant and waterlogging resistant species
• Oversowing or reinforcement with legumes
• Undersowing cereals with legumes
• Techniques for improved forage and seed production
• Pasture/forage under agro-forestry
• Seed production, processing and marketing
• Nutrition status of pasture/forages and feed budget studie
• Development activities are targeted towards:
  • Demarcation, improvement and utilization of natural pasture
  • Development of native pasture and forage genetic resources
  • Forage development in backyard, undersowing and oversowing system
  • Intensive use of fodder tree and shrubs
  • Forage development in livestock exclusion areas
  • Forage on soil conservation structures in arable areas
  • Development of broad-based adaptive research programme at farm level
  • Intensive use of crop residues and other by-products.
  • Large-scale pasture and forage seed production.

Key research and development personnel and contact people
The key research, development and contact people at various research and development Institutions in
Ethiopia are shown in Table 8.
Table 8. National pasture/forage research and development personnel and contact people

<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
<th>Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alemayehu Mengistu</td>
<td>Addis Ababa University (AAU)</td>
<td>c/o URAZ BRAHANU, P. O. BOX 62291, Addis Ababa, Ethiopia E-mail: <a href="mailto:alemayehumengistu@yahoo.com">alemayehumengistu@yahoo.com</a></td>
</tr>
<tr>
<td>Getenet Assefa</td>
<td>Ethiopian Agricultural Research Organization (EARO) Holeta Research Centre</td>
<td>P. O. Box 203, Addis Ababa, Ethiopia</td>
</tr>
<tr>
<td>Daba Geleti</td>
<td>EARO, Bako Research Centre</td>
<td>e-mail: <a href="mailto:bako@telecom.net.et">bako@telecom.net.et</a></td>
</tr>
<tr>
<td>Mesfen Dejene</td>
<td>EARO, Sirinka Research Centre</td>
<td>e-mail: <a href="mailto:sirinka@telecom.net.et">sirinka@telecom.net.et</a></td>
</tr>
<tr>
<td>Tekeleyo Abirhan</td>
<td>EARO, Bale Robe Research Centre</td>
<td>P. O. Box 208, Bale, Ethiopia</td>
</tr>
<tr>
<td>Eshetu Janka</td>
<td>Institute of Biodiversity Conservation and Research (IBCR)</td>
<td>P. O. Box 30726, Addis Ababa, Ethiopia E-mail: <a href="mailto:eshetujanka@yahoo.com">eshetujanka@yahoo.com</a></td>
</tr>
<tr>
<td>Getahun Mulat</td>
<td>IBCR</td>
<td>P. O. Box 30726, Addis Ababa, Ethiopia E-mail: <a href="mailto:Getahun2002@yahoo.com">Getahun2002@yahoo.com</a></td>
</tr>
<tr>
<td>Ali Seid</td>
<td>AAU and Bahirdar University</td>
<td>P. O. Box 3434, Addis Ababa, Ethiopia E-mail: <a href="mailto:nabiot@joinme.com">nabiot@joinme.com</a></td>
</tr>
<tr>
<td>Getachew Tadesse</td>
<td>AAU and Abiadi Teachers College</td>
<td>E-mail: <a href="mailto:gettades@yahoo.com">gettades@yahoo.com</a></td>
</tr>
<tr>
<td>Gemechu Nemi</td>
<td>MoA</td>
<td>P. O. Box 30669, Addis Ababa, Ethiopia</td>
</tr>
<tr>
<td>Hipa Feyssa</td>
<td>EARO, Melkassa Research Centre</td>
<td>e-mail: <a href="mailto:werer@telecom.net.et">werer@telecom.net.et</a></td>
</tr>
<tr>
<td>Ashnafi Mengistu</td>
<td>EARO, Adamitulu Research Centre</td>
<td>P. O. Box 35, Ziway, Ethiopia</td>
</tr>
<tr>
<td>Amsalu Sisay</td>
<td>EARO, Adamitulu Research Centre</td>
<td>P. O. Box 35, Ziway, Ethiopia</td>
</tr>
<tr>
<td>Tessema Zewdu</td>
<td>Alemaya University</td>
<td>P. O. Box 138, Dire-Dawa, Ethiopia</td>
</tr>
<tr>
<td>Ayana Angassa</td>
<td>Debub University</td>
<td>P. O. Box 05, Awassa, Ethiopia</td>
</tr>
</tbody>
</table>

8. REFERENCES


9. CONTACTS

The author, Alemayehu Mengistu, is a specialist in pasture, forage and rangeland assessment and improvement, with over two decades of experience. He has served as a visiting lecturer in Pasture and Forage Science at the Alemaya College of Agriculture, Faculty of Veterinary Medicine and Awasa College of Agriculture of the Addis Ababa University, and various agricultural colleges. From 1987 onwards till 1994 he worked as coordinator for Forage Development, and later overall project coordination of the Fourth Livestock Development Project (FLDP).

Contact Address:
Alemayehu Mengistu
Visiting Associate Professor,
Addis Ababa University,
Faculty of Science, Biology Department
P. O. Box Urael Branch, 62291
Addis Ababa,
Ethiopia
E-mail: alemayehumengistu@yahoo.com

[This profile was prepared in July 2003 by the author and was edited by J.M. Suttie and S.G. Reynolds in July/August 2003. Some updating was undertaken by S.G. Reynolds in August 2006 and Table 1 was added.]