Country Pasture/Forage Resource Profiles

ERITREA

by

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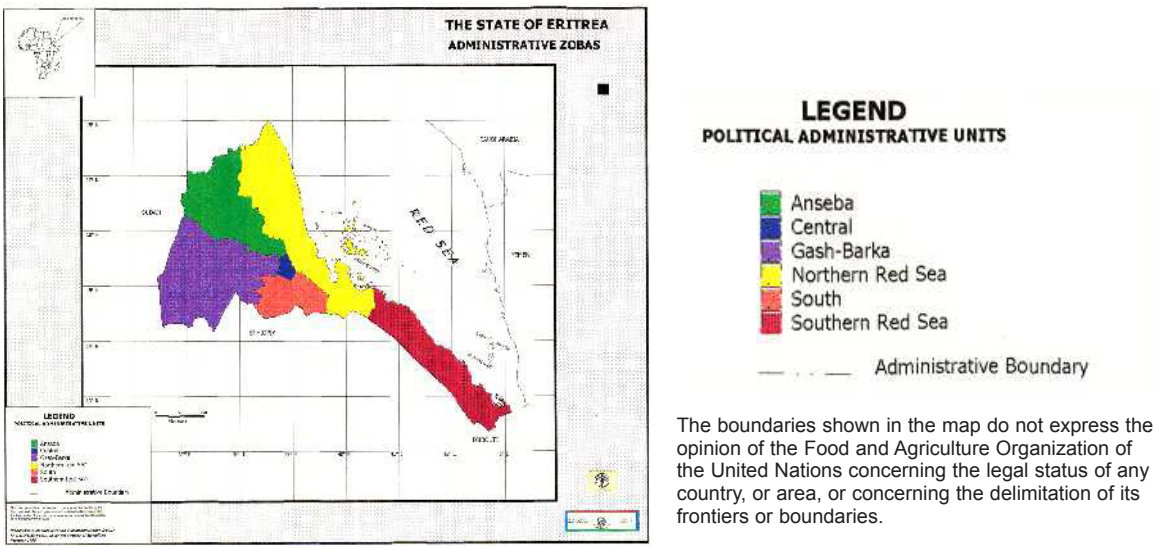
1. INTRODUCTION

1.1 Country presentation

The State of Eritrea is located between latitudes 12° 42′ N to 18° 2′ N and longitudes 36° 30′ E to 43° 20′ E, in the north-eastern part of Africa, serving as a cross-roads and a bridge between the rest of Africa and the Middle East. Eritrea, one of the countries in the Horn of Africa, is bordered by the Red Sea to the east with about 1 000 km of coastline, by Sudan on the north-west, by Ethiopia to the south and west, and by Djibouti on its south-eastern extreme (Figure 1). The country has an area of about 124 000 km^2; the population was estimated between 3 0000 000 to 3 500 000 in 2002, with an additional 750 000 refugees. The annual rate of population increase was estimated at 2.8 to 3.3% (according to the World Factbook the estimated population in July 2006 was 4 786 994 with a growth rate of 2.47%). About 65% of the population lives in the highlands, which accounts for only 16% of the land area; this population concentration in the highlands is largely due to the mild temperatures and the freedom from malaria.

Eritrea was the last African country to gain independence. It was under Italian occupation from the 1880s, between 1941 and 1952 it came under British administration, and in 1952 the newly-formed UN agreed to federation between Eritrea and Ethiopia. However, by 1962 Eritrea's status had been reduced to that of an Ethiopian province. Eritrea gained independence in 1991 after thirty years of conflict with Ethiopia, and was formally recognized as a Sovereign Nation by the international community in May 1993. The major language groups are Tigre, Tigrinya, Arabic, Afar, Bilien, Hedareb, Kunama, Nara, Rashaida, and Saho. English is rapidly becoming the language of business and is the medium of instructions in secondary schools and at university. The population is fairly evenly divided between Tigrinya-speaking Christians (mainly Orthodox), the traditional inhabitants of the highlands, and the Muslim communities of the Western lowlands, northern highlands and east coast. The capital is Asmara.

Eritrea's economy in general, and the agricultural sector in particular, were seriously affected by the combination of the prolonged war and recurrent droughts and degraded lands. The military conflict displaced farmers, reduced the availability of agricultural inputs and destroyed government support services. The GDP in Eritrea at the end of 1999 was estimated at US$ 677 000 000; GDP per capita was some US$ 200–220. The sectorial shares average 12% for agriculture, 27% for industry and the balance in the services. Nearly all crop and livestock production is based on smallholder traditional agriculture characterized by subsistence farming and low productivity, with the farming system and land tenure varying according to agro-ecological zones. The local currency is the Nakfa (1 Dollar U$ = 14 Nakfas in December 2001, but it was 9 Nakfas on October 2000).



The boundaries shown in the map do not express the opinion of the Food and Agriculture Organization of the United Nations concerning the legal status of any country, or area, or concerning the delimitation of its frontiers or boundaries.

Figure 1. The State of Eritrea - Administrative Zobas

Prepared by FAO National Food Information System (NFIS) FAO/GCPS/ERI/002/ITA for the Ministry of Agriculture, February 1998.

The present social structure of the country indicates that its population is mainly rural and that a large part of the economically active Eritreans (78% according to FAO, 1998a) are associated with "agricultural" business. The active rural population has grown from approximately 1.59 million in 1995 to 1.79 million in 1998 (Table 1)

Table 1. Eritrea - Human resources: population

	1995		1998	
	"000s	%	"000s	%
Total pop.	3 187	100	3 577	100
Agri. pop	2 519	79	2 796	78
Total active	1 592	100	1 786	100
Agri. active	1 259	79	1 393	78

1.2 Land use and crop production

Land use categories (FAO, 2000) indicate that livestock-related activities make use of 56% of the 12 200 000 ha available in Eritrea (browsing and grazing land: 6 820 000). Cultivated rainfed land accounts for 4.62% (0.56 m/ha) and irrigated land amounts to 22 000 ha (Table 2). Overall forest land represents 0.51% of the total land, or 63 000 ha. The main productive activities in the agricultural sector make a traditional use of crop-livestock associations in mixed farming and in extensive grazing; these traditional production and farming systems are characterised by low input-low output features that aim at subsistence levels.

Table 2. Land use categories

	Ha	%
Cultivated rainfed land	562 680	4,62
Irrigated land	22 000	0.18
Disturbed forest	53 000	0.43
Forest plantations	10 000	0.08
Woodland and shrub land	673 000	5.52
Browsing and grazing land	6 821 320	55.96
Barren land	4 047 000	33.21
Potential irrigable land	(600 000)	(4.92)
Potential rainfed land	(904 320)	(7.42)
Total	12 189 000	100.00

The area under cultivation and the production levels for major crops, based on government estimates, have shown steady increases since independence (Table 3). Nevertheless, production remains below consumption needs; in 1998 the gap was estimated at 590 000 tonnes, partly reflecting the recent border conflict with Ethiopia.

Land ownership comes mainly through inheritance. Within some ethnic groups, land inheritance is matrilineal (from a man to his sister's son), whereas in other groups it passes from father to son. In villages that have been established for 50 years, newcomers to the community are allocated land by village elders. In villages established during the previous 25 years, the older generation acquired its land rights through clearing of virgin land.

1. 3 Livestock population

Ruminant rearing, which includes cattle (beef, dairy and draught), small ruminants and camels, plays a significant role in the Eritrean economy and is essential for the food security of the rural population. It is basically closely integrated with crop production; it is estimated that over 20% of cattle (oxen) are kept for traction, mainly for crop cultivation. Eritrea's population is mainly rural (78%; FAO, 1998a) living from integrated crop-livestock farming systems. Land use categories (FAO, 2000) indicate that livestock related activities make use of 56% of the total 12 200 000 ha available in Eritrea. According to Government estimates the livestock sub-sector accounts for about 25% of Agricultural GDP and a significant part of the country's export earnings. Livestock is closely integrated with crop production and has a significant role in the socio-economical life of rural population in Eritrea for:

1) Draught power, food security, manure & on-farm savings bank;
2) Livestock are nearly the only activity for the pastoralist and agro-pastoralist in Eritrea;
3) Livestock offers one of the most promising opportunities for foreign exchange earnings (export to Middle East Countries), and

Table 3. Estimates of cultivated area and production (1996–1998)

Crop category	1996		1997		1998	
	Area (ha)	Production (tonnes)	Area (ha)	Production (tonnes)	Area (ha)	Production (tonnes)
Cereals	322 000	86 000	375 000	99 100	477 000	458 000
Pulses	14 000	6 400	5 800	1 200	7 000	3 300
Oil crops	35 000	5 200	13 400	2 600	16 200	11 100
Total	371 000	97 600	394 200	102 900	500 200	472 400

Source: Government of Eritrea, Ministry of Agriculture, Department of Land Resources and Crop Production

4) There is an incipient growing urban market demand for milk, meat and eggs which is presently partly supplied by many small-scale commercial livestock producers.

Table 4. Livestock numbers and production, 1998 (head)

	Total number	Domestic off-take	Expert off-take	Total off-take
Cattle	1 928 000	169 000	120 000	289 000
Sheep	2 129 000	265 000	345 000	610 000
Goats	4 662 000	910 000	590 000	1 500 000
Camels	319 000	34 000	29 000	63 000
Equines	500 000	--	--	--
Poultry	2 500 000	--	--	--

Source: GOSE (1998b)

The livestock population in 1998 is summarized in Table 4. The MOA (GOSE, 1998b) figures suggest that the population has increased substantially since 1995 (e.g. 54% increase in cattle and 24% for sheep and goats). Livestock data for the period 1996–2005 are given in Table 5 (from FAO statistical databases).

The lowlands are the livestock reservoirs of Eritrea. About 60% of cattle and goats and some 40% of the sheep and camels, or 48% of the tropical livestock units (TLU), are found in the two provinces of the western lowlands, Gash Setit and Barka. The TLU of the three central highland provinces, Hamassien, Seraye and Akele Gluzai, amount to only 23%. Oxen constitute over 50% of cattle in the three provinces of the central highlands, but only 12% in Gash Setit and Barka provinces, which are the main breeding areas. The estimated off-take of each species ranges from 15% in cattle to 32% in goats – values that seem overestimated, however many farmers returned from Sudan after Eritrea's independence bringing their animals with them.

Broad breed types can be identified based on their phenotypic characteristics; broadly divided into those adapted to the highlands or to the lowlands. The two major cattle breeds are the Barka in the western lowlands, and Arado, predominantly in the highlands and eastern lowlands. The Barka is known for its high milk production. It yields an average of 6 litres of milk per day and gives 9 to 10 litres of milk a day at the height of lactation (Sherman, 1980). The Arado is a small animal well suited to the rugged highlands. It produces hard-working oxen used as draught animals. Some European dairy cattle have been introduced since the nineteenth century by Italian settlers; some 6 000 to 8 000 cows, basically composed of pure exotic Friesian and some cross breeds, owned by 800 to 1 000 commercial farmers are concentrated in urban and peri-urban zones of Asmara.

Small ruminants are attractive to farmers because of a low initial investment relative to cattle. Goats are kept more than sheep in most parts of Eritrea, with goat production dominant in Barka, Denkal, Semhar, Senhit, Gash Setit and eastern Akele Guzai. On the borders with Sudan, there is another breed known as Shukria which is a good milker. Both fat-tailed and thin-tailed sheep are found. The thin-tailed are generally in the lowlands while fat-tailed are dominant in the highlands. The major breed of the western lowlands, known locally as Barka, is a cross between the Hamele, or thin tailed desert sheep, and the fat tailed highland sheep. The Hamale is found near the borders of Sudan and is the largest (50–70 kg liveweight).

Pack animals, mainly donkeys and some mules, with very few horses, are primarily used on farms for transportation and traction. Camels play a very important part in the agriculture of the lowlands where

Table 5. Eritrea statistica for livestock numbers, meat and milk production, sheep imports and exports and milk equivalent imports 1996–2005

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Cattle nos. (,000,000 head)	1.60	1.93	2.03	2.10	2.15	1.95	1.90	1.93	1.93	1.95
Sheep nos. (,000,000 head)	1.54	1.65	2.13	2.00	2.15	2.15	2.00	2.10	2.10	2.10
Goat nos. (,000,000 head)	1.55	1.60	1.65	1.70	1.70	1.70	1.70	1.70	1.70	1.70
Camel nos. (,000,000 head)	72	73	74	75	75	75	75	75	75	75
Beef & veal production (,000 Mt)	12.2	14.3	15.8	16.0	16.4	14.7	14.2	16.7	16.7	16.7
Mutton & lamb production (,000 Mt)	5.2	5.3	6.0	5.7	6.4	6.4	5.9	6.7	6.7	5.6
Goat meat production (,000 Mt)	5.0	5.2	5.3	5.8	5.8	5.8	5.8	5.8	5.8	5.8
Total milk production (,000 Mt)	53.5	59.8	65.2	66.5	67.5	69.5	56.7	56.7	56.7	56.7
Sheep exports (,000 head)	68.7	49.0	18.0	30.0	1.6	0	0	3.3	1.2	n.r.
Sheep imports (,000 head)	18.9	10.0	4.0	0	0	0	0	56.0	0	n.r.
Milk equivalent imports (,000 Mt)	0.4	1.9	19.0	9.1	15.2	15.2	6.7	5.4	0.08	n.r.

n.r. = no record
(FAOSTAT, 2006)

grazing and water supplies are inadequate for other livestock. Camels are an important source of food, both milk and meat, and provide transport for the produce and household goods of the nomads in the desert.

2. SOILS AND TOPOGRAPHY

Eritrea consists of a central highland mass which divides the country between its eastern and western lowlands. Altitudes vary from over 3 000 m asl in the highlands to below sea level in the Danakil depressions. The highlands have a very rugged topography, and suitable land for crops is limited to some valley bottoms. The lowlands are generally flat plains, often interspersed with hills. Most of the population in the highlands live at altitudes of about 1 500–2 000 m asl.

Soils are complex, varying from region to region in terms of texture, fertility, and other natural characteristics (Figure 2). The great majority are residual soils, that is, those developed directly from weathered bedrock. Soils that developed on the extensive basalt formations are the most fertile, those developed on the basement complex are of low to moderate fertility, and those on rocks are of low fertility (FAO, 1998b). In general, the soils are stony loams, sandy loams, or loamy sands. The rich dark clay and clay loams are commonly found in the south-west part of Eritrea, extending to the area surrounding Asmara where the densely populated villages are located. The clay and clay loam soil also extends to areas in the western and eastern lowlands. The pH range is from slightly acid to moderately alkaline.

The principal needs are organic matter in order to maintain fertility. Given the great relief of much of the landscape and generally arid or semi-arid conditions, many soils are shallow with bedrock near the surface. The shallowness of the soils reduces their ability to hold moisture for crops or natural vegetation production. Soils in the western plains include vertisols and fluvisols which, with adequate rains or under irrigation, are highly suitable for agricultural development. Soil erosion, particularly in the highlands, is very serious and losses are estimated at about 15 tonnes/ha/year (Firebrace and Holland, 1985).

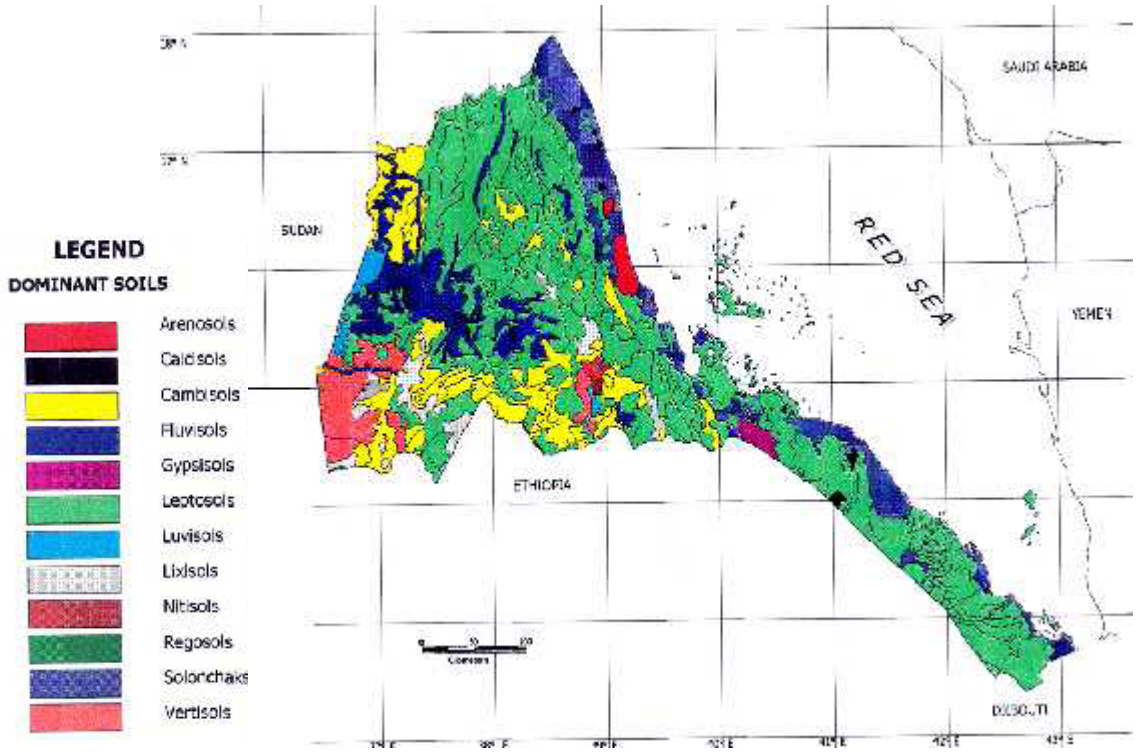


Figure 2. The State of Eritrea – Soil classification
Prepared by FAO National Food Information System (NFIS) FAO/GCPS/ERI/002/ITA for the Ministry of Agriculture, February 1998.

3. CLIMATE AND AGRO-ECOLOGICAL ZONES

3.1 Climate

The climate in Eritrea ranges from hot arid in the coastal plain areas to temperate sub-humid in isolated micro-catchments in the eastern highland escarpment. Altitude is the major factor determining temperature and rainfall. Total annual rainfall tends to increase from north to south, from less than 200 mm at the northern border with Sudan to over 800 mm in a restricted area on the southern border with Ethiopia (Figure 3). Mean temperatures range from 16 °C in the highlands to extreme highs of about 30 °C along the Red Sea coast in Massawa. The Danakil depression in the south-east, which is more than 130 m below sea-level in places, experiences some of the highest temperatures recorded, frequently exceeding 50 °C. The central highlands get a single rainy season from the end of June to late September. The western lowlands are subject to typical tropical summer rains between June and September. The north-eastern lowlands are exposed in winter to the humid winds off the Red Sea, which result in small rains which last for two to three months from November to March. The narrow strip between the highlands and the eastern escarpment (Green Belt) enjoys two rainy seasons per year.

The climate of about 70% of the country is arid with a mean annual rainfall below 400 mm and a mean annual temperature greater than 26° C (Nastasi, 1993). About 22% of the country enjoys a cool semi-arid climate. The area encompasses the high southern areas of the central highlands as well as the north. The mean annual temperature is less than 19 °C, and the mean annual rainfall is between 400 and 600 mm. This climatic zone offers the best potential for expansion of rain-fed crop production. Over 65% of Eritrea's population lives in this area. Unfortunately, increased population pressures combined with a lack of appropriate land management has resulted in serious land degradation through soil erosion. A small but important climatic area, about 0.5% of the country, occurs on the eastern embankment of the central highlands, commonly called the "Green belt". This warm to cool sub-humid climatic zone benefits from both summer and winter rains, it has the highest and most reliable rainfall in the country, up to an average of 1 200 mm annually with some rain falling in every month of the year.

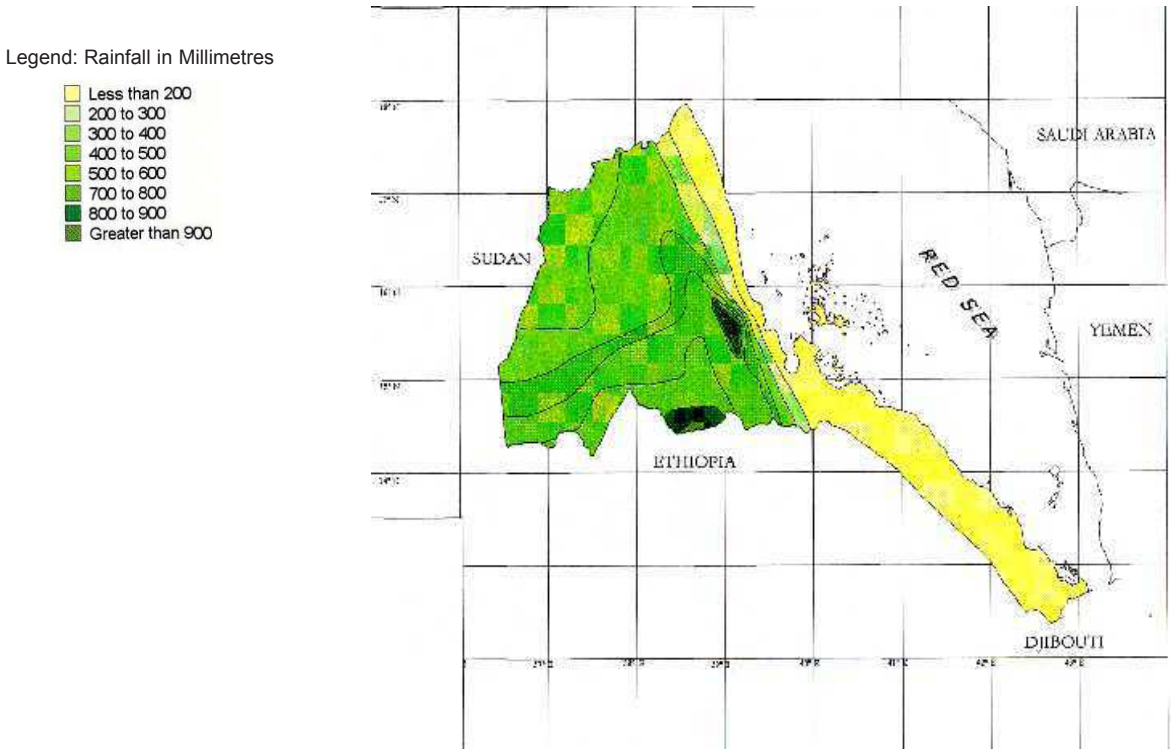


Figure 3. The State of Eritrea – Mean annual precipitation

3.2 Agro-ecological zones

Eritrea has a number of different agro-ecological zones (Figure 4) which are the following:

1. The **central highlands (CHZ)**, at altitudes of over 1 500 m, with over 500 mm of rainfall.
2. The **western escarpment (WEZ)**, at altitudes between 750 m and 1 500 m, with an average rainfall of up to 500 mm. The western escarpment is a transitional zone between the CHZ and south-western lowland zones, the SWLZ.
3. The **south-western lowland (SWLZ)**, at altitudes between 600 and 750 m with annual rainfall of between 500 and 700 mm.
4. The small **"green belt" (GBZ)** which differs from other zones in that the climate and rainfall (over 1 000 mm) permit horticulture and permanent tree crops without irrigation.
5. The **coastal plains (CPZ),** up to 600 m of altitude and only 200 mm of rainfall; and
6. The **north-western lowland (NWLZ)** between 400 to 1 500 m of altitude and less than 300 mm of rainfall.

Most agricultural production is from three zones: the Central Highlands, the South-western Lowlands and parts of the Coastal zone. Some characteristics of production in these areas are briefly discussed below and summarized in Table 6.

In the **Central Highlands**, the great majority of producers have small land holdings (average 1 ha or less), and produce mainly wheat, barley, sorghum, teff (*Eragrostis tef*), peas, beans, chickpeas and linseed. They depend largely on animal power for ploughing and threshing while small ruminants are reared for meat and milk and as a source of cash. There are communal grazing areas and seasonal migration of herds to the lowlands, especially of cattle, takes place because of lack of grazing in the highlands. A minority of producers have been able to invest in irrigation (using shallow wells and motor pumps) and produce vegetables (mainly potatoes, tomatoes, pepper and onions) on part of their land. Two to three crops are possible per year under irrigation. Productivity is good and the product is marketed locally. The standard of living of these farmers is better than those relying solely on rainfed cereals.

In the **South Western Lowland Zone**, a large proportion of the population are agro-pastoralists, with various degrees of transhumance of people and livestock. There are nomadic pastoralist tribes whose main activity is livestock rearing (primarily camels, cattle and small ruminants). There are also semi-sedentary agro-pastoralists whose main activity remains livestock rearing, but where the cultivation of

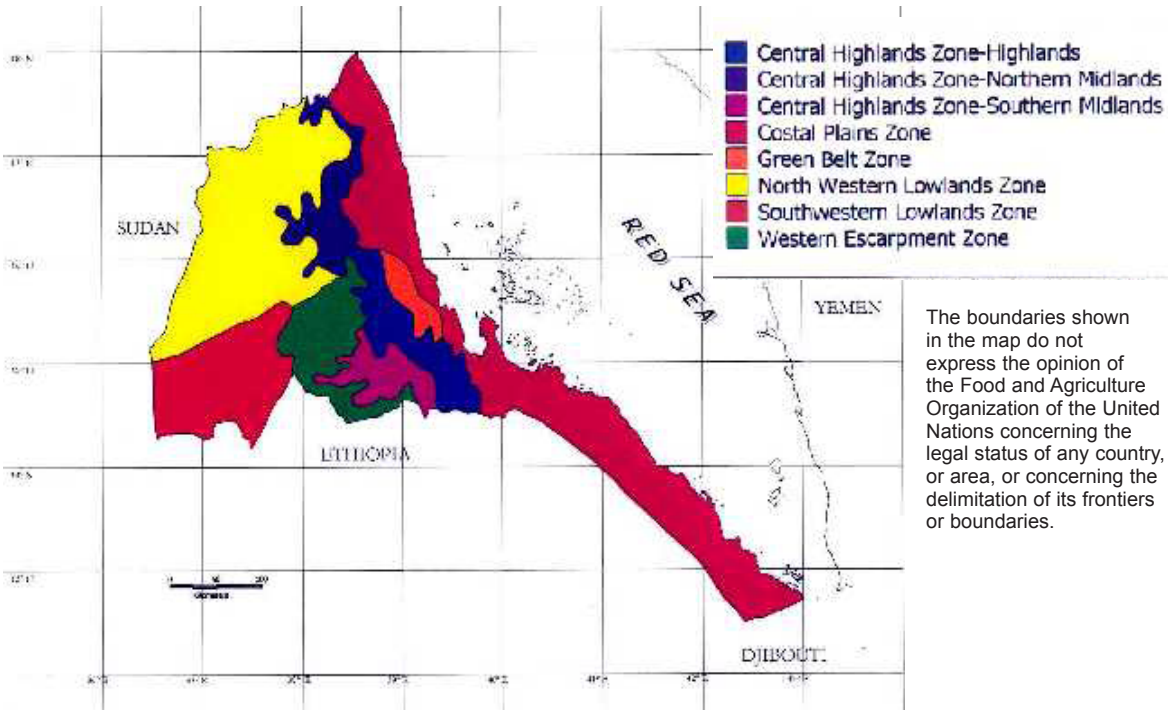


Figure 4. The State of Eritrea – Agro-ecological zones

Table 6. Summary of the main production system in the different agro-ecological zones of Eritrea

Agro-ecological zones	Production systems
I. Central Highland Zones (CHZ)	1. Rainfed cereal/pulse based system 2. Irrigated horticultural based system 3.Semi-commercial peri-urban livestock (dairy/poultry) based system
II. Western Escarpment Zone (WEZ)	1. Agro-pastoralism
III. South Western Lowland Zone (SWLZ)	1. Nomadic pastoralism 2. Semi-sedentary agro-pastoralism 3. Small-scale irrigated horticultural based system 4. Commercial farming
IV. North Western Lowland Zone (NWLZ)	1. Nomadic pastoralist system 2. Irrigated commercial fruit/vegetable based system
V. Coastal Plain Zone (CPZ)	1. Nomadic pastoralist system 2. Agro-pastoralist/spate irrigation based system
VI. Green Belt Zone (GBZ)	1. Mixed production system

sorghum, pearl millet (*Pennisetum americanum*) and sesame is significant. There are also sedentary producers practising mixed crop/livestock production where crops are more important and the family lives in one village all year round. Recently, medium and large-scale commercial farmers, favoured by distribution of land concessions by the Government and the availability of capital, have entered production. There is also mechanised large-scale rainfed cultivation of sorghum and sesame and/or medium scale irrigated plantations of bananas and citrus supplying Asmara and export markets. Most of the irrigation water is from wells.

Some parts of the Coastal Plains have a potential for crop production. These are in the Eastern Lowlands where spate irrigation exists and has the potential for further development. The main activity remains rearing of mixed herds of camels, cattle and small ruminants with seasonal migrations towards the highland areas in the hot dry season. However, an important activity is sorghum growing using short duration spate flood flows diverted into fields. Growing sorghum or maize on residual moisture is possible in years where moisture retention is good, and there is the potential to introduce new crops (such as vegetables and forage for intensive production mainly of small ruminants) into the system.

In the CPZ and NWLZ, crop production is only possible with irrigation, and livestock production is predominant. Although pasture resources are poor to moderate, the economy of these zones is largely based on extensive transhumant pastoral systems.

4. RUMINANT LIVESTOCK PRODUCTION SYSTEMS

Livestock management practices vary considerably in different agro-ecological zones. In the highlands, cereals and livestock are managed in closely integrated systems where animals (mainly oxen and small ruminants) graze hillsides and stubble left on fields after harvest; and crop residues are also stored and used as supplementary feed during critical periods. Livestock numbers are given in Table 5. The majority of the livestock are in the lowlands, of which 71% of the cattle, 50% of the sheep and goats and 60% of camels are in the western lowlands. In low rainfall areas agro-pastoralists complement their grazing livestock with crop residues while the pastoralists migrate long distances in search of grazing (semi-sedentary systems) and are adapted to the arid conditions of the marginal zones. Except for some peri-urban commercial production, livestock production is primarily carried out by the traditional sector under natural conditions. Traditional production systems vary within the different ecological zones:

a) **Central Highlands:** Rainfed farming being the main agricultural activity, annual crop production is the major objective. Population pressure is forcing people to convert grazing land into crop land, thus relegating livestock to rocky and steep hills with low grazing potential. The increased agricultural area, in turn, results in a higher demand for oxen in a situation where the grazing area has already declined. Hence, more draught oxen have to be retained at the expense of milk cows and other animals. That is why over 50% of the cattle in the Highlands are oxen. The major feed sources in the highlands are communal grazing and scrub lands and crop residues, including the grazing of crop stubble.

b) **Western Lowlands:** Most of the livestock in the Western Lowlands are raised on natural grazing under pastoralist and agro-pastoralist systems. In this area the traditional practice is to use wet and dry season camps. The former relate to the pastures near the permanent homes, north of the Gash river, and the latter to pastures south of the Gash up to Tigray province in Ethiopia (see Figure 1). Livestock graze up to November in the wet season camps because of the availability of green pasture and water. In December or January, as the pastures become depleted and water scarce, the pastoralists start to trek their animals to the dry season camps, between the Gash and Setit rivers, and into Ethiopia (see Figure 1). With the onset of rains, the pastoralists trek back to their wet season camps to join their families, and to avoid the blood-sucking insects which breed in the wet season. Their objective is to produce milk for themselves, ghee for sale, and to increase the number of their animals. Hence, offtakes are low - below 10%. The reasons for increasing the numbers as much as possible are for prestige and as a guarantee against drought. There is now some conflict between pastoralists and farmers (concessions and settlements) because farming is blocking some of the traditional livestock routes and animals are damaging crops.

c) **Eastern Lowlands**: With the exception of a few areas of spate irrigation, where agro-pastoralism is practised, livestock production in this area is based on pastoralism. The distances covered are, however, much shorter than those in the Western Lowlands. Livestock are grazed on natural pasture for a few months in the rainy season (December to March), depending on the duration of the rains and then moved to the eastern escarpment slopes. The dominant animals are goats which are kept for some milk, but mainly for meat sales. In areas of spate irrigation livestock are fed with crop residues, sorghum rations and sown forage is grown. Dairy animals are stall-fed.

d) **Peri-urban Livestock Production**: Dairy production has been carried out since the nineteenth century by the Italian settlers. The commercial dairy industry had much suffered during the long war, however, after independence dairy activities have restarted with the support of the Asmara Dairy Farmers Co-operative Association (ADFA), which owned a milk processing plant and a feed mixing plant, and organized milk collection and feed distribution. Nowadays, dairy production is basically concentrated in urban and peri-urban zones of Asmara.

The situation of the peri-urban dairy producers is extremely precarious. Most producers have lost their forage producing farms and retreated to the urban area. The farms now have no forage producing capacity, and operate through the purchase of hay and straw from farmers and some industrial by-products. The nutritional condition of the animals is poor and milk yields low. During a survey on the peri-urban dairy sector (Kayouli and Assefaw, 1999), it was pointed out that poor and inadequate nutrition is the basic cause of low milk production and poor reproduction. Although there is no dairy record keeping on individual milk production, it is obvious that the milk yield per lactation from Holstein Friesian cows is still far below their genetic potential. The total daily milk production from 130 milking cows visited in 7 dairy farms in and nearby Asmara was only 1 173 litres or 9 litres/milking cow/day.

Among the major constraints limiting the potential development of livestock production, inadequate feed has been identified as the crucial bottleneck. The bulk of livestock feed in Eritrea comes from grazing on pastures, stubble and residues which are often of poor quality. In most areas, especially during the dry period, common daily rations cannot even meet maintenance requirements during several (at least six) months. Most ruminants are consequently submitted to chronic under nutrition: they lose weight in the dry season and early wet season, and this makes them more vulnerable to disease. Poor nutrition affects work oxen performance, showing lower efficiency in ploughing. Some other constraints include:

1. shortage of know-how among trained technical personnel and limited practical skills of smallholders,
2. the livestock sub-sector as well as the cropping system are primarily smallholder based, where management practices are very traditional using no external inputs or technical advice, and
3. the extension service is very weak and there is a serious shortage of qualified extension people.

5. THE PASTURE RESOURCE

In terms of the forage and pasture resources not much research has been done, most of the information that is therefore documented is really not derived from research activity, but is based on general descriptions from survey type work and some development projects. However, it should be borne in mind that the initial potential for increasing the total feed resource is by optimising the natural production of the specific ecological zones.

The bulk of livestock feed (estimated to be about 90%) comes from grazing on pastures and stubble, conserved crop residues (straw and stover from sorghum, millet, wheat, barley, teff, maize, industrial crops) and agro-industrial by-products that include linseed and sesame cake, cotton seed and cotton seed cake and wheat bran. In general, forage supply shortages are amplified by their poor quality. In addition agro-industrial by-products are often inefficiently used and likewise crop residues are fed without treatment or supplementation. The limited locally grown forages for livestock production is not the only main problem, but management practices of forage production and its inefficient utilization is the one that causes under nutrition as a major factor in low productivity of livestock. The overall feed balance in Eritrea indicates that feed is in short supply by 20% in terms of energy and 30% in terms of protein requirements (FAO, 1994). The main feed resources are the following:

5.1 The natural pastures

Livestock are sustained by grazing the natural pasture comprising mostly fast maturing species, and various shrubs and trees like *Acacia albida, Acacia seyal, Balanites aegyptiaca, Acacia senegal, Terminalia brownii, Acacia mellifera, Capparis decidua, Acacia tortilis, Acacia asak, Diospyros abyssinica, Acacia nilotica, Ziziphus spina-christi and Albizia lebbeck* are also available during and shortly after the rainy season. Annual rainfall is the main factor influencing the availability of feed on the pastures. According to FAO (1995) the production of feed, in dry matter (DM) terms (kg/ha), under different rainfall regimes (mm/year) and the relative animal carrying capacity (ha/Tropical Livestock Unit), have been estimated as shown in Table 7:

The amount and quality of native pasture available to livestock varies with altitude, rainfall, soil and cropping intensity. Depending on the climate, different types of pasture grow in different agro-ecological zones of Eritrea. A close relationship exists between pasture and climate as a consequent of plant evolvement and adaptation over long periods of time. Because of this interaction dominant natural pasture groups have become associated with a particular climate. The status of the different rangelands is discussed below.

Central highlands: The pastures in the highlands are infertile and steep, hence fragile under continuous uncontrolled grazing regimes. The grazing area has been shrinking over the years because of over-grazing, extensive cultivation, improper utilization of water resources and deforestation. The removal of forest cover and constant grazing have depleted the resources of the browse layer. The pastures have no opportunity to recover because hungry animals are continuously searching for any edible plant that sprouts. Attempts to allow regeneration by closing land to grazing have shown promising results and are becoming models for recovery. However, generally because of the above-mentioned reasons the most palatable species of herbage and browse are decreasing in quantity and leaving space for less palatable species. If the present trend of deterioration persists for much longer, it may not only destroy the palatable species completely but it could also change the land to bare soil and initiate the process of desertification. Natural grasses of the central highlands include species of *Pennisetum clandestinum , Chloris gayana, Digitaria abyssinica, Digitaria scalarum, Setaria sphacelata, Cenchrus ciliaris, Cenchrus mitis, Eragrostis cilianensis, Eragrostis superba, Andropogon* spp., *Bromus pectinatus, Dactyloctenium aegypticum, Hyparrhenia hirta, Brachiaria semiundulata, Heteropogon contortus,*

Table 7. Estimated DM production and carrying capacity

Rainfall (mm)	Total above ground DM production (kg/ha)	Carrying capacity (ha/TLU)
100	n.a.	over 20
200	450	17
300	675	10
400	900	7
500	1 125	6
600	1 130	4

Melinis repens, Avena fatua, Eleusine indica, Cynodon dactylon, Denebra retroflexa, Echinochloa colona, Themeda triandra and *Sporobolus natalensis* (GOSE, 1998a).

Western lowlands. In the wetter southern part of the western lowlands, there appears to be no damage to the rangelands, except in those areas adjacent to population centres. The intensity of grazing increases in the drier northern part of the lowlands, where the grass becomes relatively scarcer. The extensive and migratory system of animal husbandry allows the rangelands to recover, unlike in the highlands. However, if the present system of uncontrolled grazing continues with a larger animal population, the fate of the rangelands will be similar to that of the highlands. The vegetation of this agro-climatic zone presents a picture of great complexity, comprising a wide variety of vegetation types, which may be called semi-arid tropical. The dominant grasses observed are species such as *Andropogon dummeri, Digitaria diagonalis, Setaria sphacelata, Chloris virigata, Eragrostis cylindriflora, Eragrostis cilianensis, Eragrostis superba, Cyndon nlemfuensis, Aristida adscensionis, Dactyloctenium aegyptium, Elytrophorus spicatus, Aristida funiculata, Eragrostis macilenta, Eragrostis tremula, Cenchrus biflorus, Enteropogon macrostachyus Cyperus rotundus* and *Aristida mutabilis.*

Eastern lowlands. This region is arid, having annual temperatures varying from 28–38 °C with little seasonal variation. Pastures are of low productivity and not in good condition in terms of ground cover, as grasslands and browse are limited within a vast desert. Grasses, which occur naturally, include species of *Cynodon* spp*., Cenchrus prieuri, Eragrostis cilianesis, Aristida mutabilis, Eragrostis cylindriflora, Eragrostis superba, Elytrophorus spicatus, Panicum triticeum, Paspalidium gemminatum, Sporobolus spicatus, Cyperus rotundus,* and *Aristida adscensionis*

The pastures are overstocked mainly in the dry season. In many places the soils are severely degraded and have lost much of their water-holding capacity. The pastures are subject to sheet and gully erosion with the onset of and for the duration of the rains. Erosion has resulted in several areas in a significant shallowing of the topsoil generally, and poor seed set in the heavily grazed areas. This is a significant constraint to productivity in pasturelands, which consist almost entirely of annuals.

5.2 Other feed resources

After natural grazing, crop residues are the most important feed sources, particularly in the highlands. Almost every farmer stores straw, mainly barley, wheat and teff straws (in the highlands) and sorghum and pearl millet stover in the lowlands. The animals would not survive until the next rainy season if they did not have straw. Even with this supplement they barely survive and are weakened. Stubble grazing of harvested fields also gives the animals a chance to supplement their browse, or to enable the grazing land to rest for some weeks. The villagisation of former pastoralists in the lowlands and their transfer from pure pastoralism to livestock raising and cropping has increased the demand for crop residues, which are highly valued and commonly traded. However crops are reported to fail five years in ten in the low rainfall belt and three years in ten in higher rainfall areas in the lowlands. The supply of crop by-products, which might otherwise be available for supplementation, is reduced or fails entirely in these years.

Available high value feeds include industrial by-products such as brans, oilseed cakes and brewers grains. The output of bran from the main large-scale government processing plants is some 15 000 tonnes/year, and this is sold to small-scale commercial livestock producers. The amount of bran produced by the widely scattered small mills is not known. Oilseed cake (cotton and sesame) production is about 5 000 to 6 000 tonnes/year. About 10 000 tonnes of wet brewers grain are also produced by the Asmara brewery (FAO, 1995). In the past, fish meal was an important source of feed as Eritrea used to export some 5 000 tonnes/year in the early seventies. This resource is now unused following the collapse of the fish industry, but fisheries development is again emerging.

All these feed sources do not suffice to meet the requirements of the producers, and there is a need to create conditions for the commercial farmers to produce their own fodder, as in the past. At present, a few producers who have land and irrigation facilities grow green fodder, mainly lucerne (*Medicago sativa*). Some farmers feed prickly pear *(Opuntia ficus-indica)*, it is de-thorned and chopped before feeding [for details of cactus pear as forage and a recent FAO publication entitled Opuntia as forage].

However, cactus cladodes should be used with other feeds to avoid the severe laxative effect which occurs when used as the sole diet ingredient. During the dry season farmers usually run out of conserved straw, which results in them feeding cactus in unlimited amount without mixing with straws, which has resulted in considerable livestock deaths particularly in the highlands.

5.3 Pasture conservation in reference to the eco-zones

Lack of feed is a major constraint to livestock production and productivity in Eritrea. This is mainly due to continuous drought, overgrazing and acute shortage of grazing land in the highlands which exacerbates the problem and limits livestock numbers. In order to feed livestock all the year round, excess feed produced during the rainy season must be conserved for the coming long dry season. The materials conserved for livestock feed in each eco-zone differ in type and quality. However cereal straws are commonly conserved in the highlands and stovers of sorghum and pearl millet are conserved in the western lowlands.

In most eco-climatic zones the community owned enclosures for grazing are taken to be a conservation system in which grazing is mainly for oxen and the injured animals until they are cured, or for newly calved cows for short periods. In the central highlands and the western lowlands grazing in the community owned enclosed land is for all animals, and community doesn't specify any class of animal. These enclosed lands are operational only for a maximum of two to three months. Unlike in the western lowlands, in the highlands oxen are allowed to graze daily, whether they plough or not ,whereas for other animals they are excluded until the onset of the main rain in June. The enclosures become free for all types of animals from the end of June to early August, after which they are enclosed again.

6. OPPORTUNITIES FOR IMPROVEMENT OF FODDER RESOURCES

As indicated earlier, Eritrea is a relatively young independent nation that is only now organizing its incipient livestock research agenda. In terms of the forage and pasture resources little research has been carried out; most of the information that is therefore documented is really not derived from research activity, but is based on general description from survey type work and some development projects. However, it should be borne in mind that the initial potential for increasing the total feed resource is by optimising the natural production of the specific ecological zones. Under the current systems of constant and complete utilization of the ground layer of natural forage, the total production of edible grasses and herbs does not reach the maximum yield potential as determined by the specific rainfall regime.

6.1 Cultivation and use of high quality legumes and grasses

Many farmers produce high value crops such as fruit and vegetables under small-scale irrigation. There are opportunities to complement the cropping system with the production of high quality, high value fodder. Production of legumes such as lucerne, cowpeas and vetch would provide an extra source of income while maintaining soil fertility. This has been carried out in the Ministry of Agriculture regional offices and under the supervision of the Animal Resource Department. Spate irrigation which it is often done in the Sheab areas in the eastern escarpment zone provides an opportunity for large-scale production of high quality fodder of sorghum and pearl millet stover. This is a cost-effective approach as the water and fertile, alluvial soil is delivered naturally. Renovation and expansion of spate irrigation systems will increase their capacity to supply fodder, for harvest and sale or use in animal production on site. Also, the integration of forage with crops would optimise both its short-term financial returns and long-term sustainability. Forage production fills a number of roles: strips of sown, perennial pasture between crops prevents erosion and provides high quality feed to supplement diets of crop straws; and leguminous forage contributes to the nitrogen budget of the system, assisting in maintaining soil fertility.

A number of exotic annual and perennial high potential grasses such as oats (*Avena sativa*) Sudan grass (*Sorghum sudanese*) Rhodes grass (*Chloris gayana*) and elephant grass (*Pennisetum purpureum*)

as well as legumes have only been introduced quite recently to Eritrea and are now being evaluated in adaptation studies. Preliminary trial results on several of these forages at Halhale Research Station (Highlands) are very promising. As an example, elephant grass (*Pennisetum purpureum*) yielded 25 ± 6 tonnes dry matter/ha/year in ten cutting

6.1.1 Under rainfed conditions

Cultivation of forages would increase the output from cut-and-carry feeding systems and thus improve livestock performance, mainly in dairy and fattening operations. Action should be taken on oat, vetch and sorghum-sudanese for the Central Highlands Zones. Mixed cropping of vetch-oat should be tried to produce good energy-protein balanced forage, from this mixture. Some highly productive, perennial grasses could be also tried such as: *Pennisetum purpureum* (Elephant grass), and *Chloris gayana* (Rhodes grass). Similarly, establishment of mixed grass legume pastures (Rhodes grass, *Setaria* and *Desmodium*) could be tried on enclosed land On the other hand, feed crops for use in integrated livestock/crop production system such as sorghum:Lablab and sorghum:cowpea should be tested in the Highlands as well as in the Western Lowlands Zones. *Lablab purpureus* is particularly interesting as a drought tolerant fodder.

6.1.2 Under traditional irrigation system

Areas under irrigation, both in the Central Highlands Zone and the Western Lowlands, would focus their efforts mainly on high production forage legumes, such as lucerne, cultivated for intensive cut-and carry feeding of dairy animals. This would include peri-urban dairy producers. Some experience is available in operating these systems but improved management and feed utilization of irrigated pasture is still required. When the supply of irrigation water is sufficient, trials could also include dryland species and rainfed species; growing elephant grass on the boundary of irrigated plots could be considered.

6.1.3 Under spate/flood irrigation

Spate irrigation provides an opportunity for large-scale production of high quality fodder. This is a cost-effective approach as the water and fertile, alluvial soils are delivered naturally. Renovation and expansion of spate irrigation systems will increase their capacity to supply fodder, either for harvest and sale or for use in animal production on site.

6.2 Pasture reseeding

The natural grasses of Eritrea are the best-adapted ones for each ecological situation. This is indicated by the fact that varieties of such genera as *Andropogon, Cenchrus, Chloris* and *Digitaria* are now sown in many countries as improved pastures. However, some reseeding may be desirable in areas where the grasses have been completely destroyed. A higher priority is to introduce leguminous forage into natural grazing as there are few high quality herbaceous legumes. Introduced forage species (both woody and herbaceous) can be established by broadcasting them on untreated rangeland. However, cultivating the site, creating micro-water pondage and removing animals during plant development significantly increases their chances of success. The chances of success with over-sowing programmes is high in areas receiving at least 500 mm of rainfall annually with species selected for their productivity and tolerance to drought. Anticipated increases in dry matter yields are a minimum of 50%. Avoidance of constant complete removal by livestock is required in order to obtain significant benefit from such rangeland reinforcement. It is necessary, of course, to correct the management faults which caused the deterioration.

6.3 Establishment of fodder trees and the use of foliage to supplement animal diets

Browsing and grazing provide about 90% of feed consumed by ruminants in Eritrea; their supply declines rapidly in quality during the long dry season. Planting fodder trees is gaining popularity in many tropical countries and particularly in the semi-arid zone where they have been developed for multipurpose productive use. In Eritrea legume fodder trees/shrubs have great potential as a source of protein and minor nutriments, to supplement diets of large and small ruminants normally fed nutritionally unbalanced and low digestibility roughage such as natural pasture, stubble and untreated crop residues.

There are hundreds of fodder tree species in the world which belong to more than 40 botanical families and a wide range of productive features is also found within species. In Eritrea development efforts on fodder trees would be carried out according to agro-ecological zones.

6.3.1 Highlands

Tree legumes such as *Leucaena leucocephala*, *Sesbania sesban* and the shrub *Cajanus cajan* have a very great potential for use in both the Central Highlands Zones (CHZ) and in valley beds of the Western Lowlands, in areas with 600 mm and over of rainfall. Cactus pear (*Opuntia* spp.) is another forage found widespread in Eritrea particularly in the highlands; which has not been suitably tested to date as a potentially valuable feed. Spiny cactus is currently widely used for fruit in the Highlands. *Opuntia* spp. are well known as an emergency drought feed for cattle when, although grasses have become dry and over- grazed, the cactus remains succulent and green.

6.3.2 Lowlands

Fodder tree research in Western and Eastern Lowland Zones must enjoy the highest priority on account of the high density of the animal population and frequently recorded feed shortages (drought, low rainfall) mainly with settled people. The fodder tree development research programme for the lowlands should be stratified to address specific features encountered in each sub-ecological zone met in those areas. Special emphasis should be given to studies related to the best adapted shrubs to arid and semi-arid conditions, to species which are tolerant to poor soil fertility and low rainfall and are drought resistant (species with deep-root systems that have easier access to water and nutrients). The main fodder trees to be examined would be the following:

Leucaena leucocephala and the shrub *Cajanus cajan* (Pigeon pea) would be the main ones to be tested in zones where rainfall is in excess of 400 mm, especially in the Western Escarpment Zone. Many natural shrubs are well adapted to marginal and dry areas found in Lowland zones and species such as *Acacia albida, Acacia tortilis* and *Prosopis juliflora* are very resistant to drought; their foliage and pods are often a valuable resource where plant cover is very poor.

Extensive pastoralism is practised in many parts of the Coastal Plains Zones under hot desert climate and a very low rainfall of less than 200 mm. It is recommended that introduction trials of *Atriplex nummularia* be done in these areas; it is one of the best-adapted shrubs in term of forage. It makes a very significant contribution to the diet of camels and small ruminants, especially during the dry seasons and droughts that are common in this region.

6.4 Improvement of nutritive value of poor quality forage and grazing land

The grazing of poor quality pasture and crop residues are the traditional resources used in ruminant feeding. Two appropriate feeding technologies based on better utilization of locally available feed resources have been successfully tested and are now well established at Halhale Research Station in the highlands: urea treated straw and the manufacture and utilization of feed-blocks. Their effects on consumption and improvement of the nutritional quality of the straws is substantial and their effects on animal growth have also been positive. As a part of livestock research activities of the Project "Strengthening the Agricultural Research and Extension Division" (FAO-GCP/ERI/001/ITA), a three-month sheep trial cycle was carried out (April-May-June 2000) aiming to investigate the effect of urea treated straw and feed blocks on intake and liveweight of sheep during the critical dry season (Kayouli and Asssefaw, 2000). Straw intake was substantially increased (15%) when animals were supplemented with feed blocks; urea treatment has notably increased straw intake (35%) and urea treatment and/or feed blocks have significantly improved sheep liveweight during the critical dry season.

7. RESEARCH AND DEVELOPMENT ORGANIZATIONS AND PERSONNEL

Department of Research and Human Resources Development, Livestock Research Unit (Ministry of Agriculture-Eritrea).

- Dr. Tzeggai Tesfai, Head Livestock Research Unit. Dr. Tseggai is a Veterinarian by training and as such was Head of the Central Diagnostic Laboratory. Currently he is conducting research in the use of locally available genetic resources (animal and plant, including forage resources) looking at strategies of matching nutritional management systems to those of the rangelands as well as animal biotypes. At present his responsibilities include the leadership of livestock research in Eritrea that gives him the responsibility of supervising several research staff and international consultants in his area.
- Tecle Abraham, is working with breeding and nutrition of sheep.
- Kahsai Andegaorgis, is working with dairy cattle management.
- Mihreteab Yemane, is working on range management and livestock production systems.

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