CERTAIN ASPECTS OF THE DAIRY SYSTEMS IN THE HARAR MILKSHED, EASTERN ETHIOPIA

by

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DECLARATION

I hereby declare that this dissertation submitted by me to the University of the Free State for the degree, **Philosophiae Doctor (Ph D)**, is my own independent work and has not previously been submitted for a degree at any other university. I furthermore cede copyright of the thesis in favour of the University of the Free State.

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CHAPTER 1

GENERAL INTRODUCTION

Meeting the need of urban populations for food is of growing concern in developing African countries. The demand for dairy products in Sub-Saharan Africa generally exceeds the supply in most areas (Brokken & Seyoum, 1992). Over the last few decades, the rapid population growths in Sub-Saharan Africa, combined with the rise in per capita income have caused a rapid growth in food consumption, in particular for dairy products.

Much of this increased demand for dairy products will be concentrated in urban and peri-urban areas. The population in Sub-Saharan Africa is expected to increase by 2.75% per annum between 1990 and 2025, resulting in an additional 800 million people to feed. More than 500 million of these people will be living in cities and large towns. Meeting the food needs of these people will present an enormous challenge to African farmers and their governments for whom welfare of urban consumers is becoming a major political concern (World Bank, 1989; Winrock International, 1992).

The World Bank (1992) has estimated that the demand for dairy products in Sub-Saharan Africa will increase by about 5.5 million tons by the year 2025 at an annual growth rate of 4%. There is serious doubt if this need could be met by the local farmers.

Almost the same challenge is being faced in Ethiopia. The human population in Ethiopia, currently (year 2002) estimated at 60 million, is growing at about 3.5% per annum. This number of people will increase to about 130 million by the year 2020, making Ethiopia the third most populated country in Africa (ECSA, 1995). The number of children under the age of 15 is projected to increase from 26.7 million in 1994 to 59 million in 2020, and the number of women in peak child-bearing age is estimated to reach about 15 million women by 2020. Urbanization was projected to grow to 39.2% by year 2000 (ECSA, 1995).

Currently, the cattle, sheep and goat populations in Ethiopia are 30, 23, and 17 million respectively, with an estimated annual milk production of 800 000, 65 000 and 95 000 metric tons for the three species respectively (ILRI, 1993). The average annual cattle milk consumption was estimated at 1 101 000 metric tons during the period from 1975 to 1987 and the per capita consumption was 25.6 kg/year. This consumption is low compared to other Sub-Saharan African countries and far below the 200 kg/year of developed countries (ILCA, 1993).

In Sub-Saharan Africa, including Ethiopia, there are three major livestock production systems. These three systems, namely pastoralist (nomads), agro-pastoralist (semi-sedentary) and crop-livestock (sedentary) production systems are based on small-scale farmers and predominantly utilize indigenous animals and traditional land use practices (Walshe, 1992).

According to Janke (1982) and Alemu (1997) the crop-and-livestock integrated farming systems can further be divided into two broad sub-divisions namely: crop-livestock and livestock-crop systems. In the crop-livestock system, cropping is primary and the more important farming activity, while livestock is secondary. In the livestock-crop system the livestock is the primary activity and cropping takes secondary position in terms of farming importance.

In the pastoralist and agro-pastoralist production systems, milk marketing is not a major business, whereas selling of milk assumes importance in the peripheries of large cities and towns in the crop-livestock production systems. The concepts of small-scale farmers and mixed-farming have various forms and characteristics, depending on the specific perspective from which it is viewed. When the concept of small-scale farmers is considered in terms of market relations, farmers are operating at various levels ranging from predominantly subsistence to market-oriented producers (Doppler, 1991). Based on the relative access to key resources and the level of external input procured, the system is characterized as low external input agriculture, with a shortage of capital and relative abundance of labour. The relative abundance of unqualified, unskilled labour is used to increase or sustain output of crops and livestock from the land, which means that the system operates in a labour intensive manner rather than a capital intensive manner (Schiere, 1995).

Harar is the capital of the Harari region and is located 500 km east of Addis Ababa, the capital of Ethiopia. The agricultural production systems in the eastern regions of Ethiopia in general, including Harari, are predominantly mixed-farming systems, where crop and livestock are highly integrated. In the Harari region mixed-farming, based on multiple crops and livestock species, is practiced to secure subsistence of the small-holdings. There appears to be no alternative but to integrate crops and livestock and practise mixed-farming to meet the need of these farmers. Indeed, the diversity of agricultural practices are not only a means of diversifying yield and income, but also an effective way of averting or spreading the risks of loss from bad weather, diseases or unfavourable markets (Wibaux, 1986).

In the Harari region, sorghum and maize are the major crops, providing staple food to people and various forms of feed and by-products to livestock. Assuming that the average person requires the energy equivalent of 300 kg of cereals/person then even the most productive 1 ha plots (the average plot size per household in the Harari highlands is less than 1 ha) of sorghum or maize are far from being able to meet the minimum grain energy requirement of a family with five members (Jahnke, 1982).

In Ethiopia small-scale farmers use local zebu cattle breeds as a major source of milk production. The average milk production of indigenous cattle in Ethiopia is estimated at 213 kg/cow/lactation (Brannang *et al.,* 1980; Schaar *et al.,* 1981; Kiwuwa *et al.,* 1983; Kebede, 1992; Kurtu *et al.,* 1999). Traditional management practices are used to produce milk that is used either for home consumption or is sold at local markets, usually processed into butter and A*yeb* (cottage cheese). In the Harari region, however, milk is mostly sold in a fresh form and seldom processed to butter and cheese (FARM-Africa, 1996). The national shortfall in Ethiopia between demand and supply has been estimated at 2.7 billion liter of milk per year (Tegegne & Alemu, 1998).

The rapid growth in consumption of dairy products has been principally covered by imports of basic staples at a growth of 7% per year. Commercial imports of dairy products in Sub-Saharan Africa have increased steadily since 1960 and in 1980 it absorbed about 5% of the region's total revenue from agricultural, forestry and fishery exports (Von Massow, 1989). Most Sub-Saharan countries cannot sustain this situation.

Although it is inadequate to meet the increase in demand, market-oriented dairy production is already increasing in most African countries, including Ethiopia. This is a direct response to consumer demand and improvements in the infrastructure in rural areas (better road systems and input markets) as a result of rural development efforts to promote small-scale farms as well as more commercially oriented producers. This trend is becoming common in various parts of Ethiopia, such as Addis Ababa, Debrezit and Harar where more market oriented small-scale and medium size dairy operations are found. For small-scale farms, dairy production allows year-round employment of the family labour force, it provides a means of intensifying land use when it is a limiting resource and milk often also assumes the role of a "cash crop", hence ensuring a regular income.

Acknowledging the fact that dairy producers may find a primary market among their rural neighbours, many under exploited market opportunities exist in nearby urban areas, where the challenge is to meet consumer demand. Producers who are targeting urban consumers have access to larger markets and better prices, and hence achieve higher returns than if they were to target only local, rural consumers. It is more likely that increased supply may result from an increase in the current herd productivity and from more efficient marketing channels, rather than from an increase in the size of the producing herd.

The development of dairy production aimed at a "distant" market, unlike the traditional way that only aims at restricted neighbouring areas, is a new trend in Ethiopia. As can be expected with new trends, it is currently at various stages of development around different consumer centres, with some variation in its components (Walshe *et al.,* 1992). Currently, the emerging and fast growing urban and peri-urban dairy production systems, operating at different levels of intensification are becoming important farming systems in many areas of Ethiopia, including Harar town. However, very little information is available on this emerging but very important activity. Therefore, further expansion and the sustainability of these production systems need careful evaluation and understanding, because in general dairy production requires a relatively large capital investment, large feed resources and a long-term commitment (Tegenge *et al.*, 2000).

The current milk deficit, combined with the projected increase in demand as a result of both population and income growth, represents a major market opportunity for domestic dairy producers, especially in urban and peri-urban areas. As a consequence, the magnitude of the challenge and the good prospects for market-oriented dairy production in many regions in Ethiopia have become a priority for research and development agencies. Development agencies are urgently looking for adapted means to overcome a number of constraints and difficulties that still have to be identified. At a national level the Ethiopian Agricultural Research Organization (EARO) has repeatedly stated the urgent need for information and methodologies to plan and implement relevant interventions on dairy systems in general and those around Harar in particular.

However, before any intervention is made in the Harar milkshed it is important to know and understand the dairy systems operating in the Harar milkshed. The Harar milkshed in this study refers to the area in and around Harar, where milk is produced and supplied to the Harar town. It is important to characterise the various dairy production systems in terms of animal type, feed resources, feeding practices, general management, milk technologies, and milk delivery and marketing systems. This characterisation should be done with a holistic approach. All dairy production systems should be viewed and their constraints and problems relevant to each component or sub-system should be identified so that specific and pertinent interventions can be used rather than having to resort to a blanket recommendation across the board which have not yielded expected results so far (Rey *et al.,* 1993).

The available literature have not yet adequately characterised the Ethiopian dairy production systems in a holistic approach. For example, the importance of urban and peri-urban dairy production for the existing milksheds have not been adequately studied. The specific contributions of rural women, to milk production, processing and delivery have not been properly assessed and documented particularly in the Harari region. This urgent need can best be done through a diagnostic survey, geared towards defining the general features of dairy production systems in the Harar milkshed. Such a survey should include the animal resource, the quantity and quality of the feed resources, feeding systems and general management practises, milk production levels and the role of women in milk production, processing and marketing.

The EARO and The International Livestock Research Institute (ILRI) recently carried out studies to characterise the dairy production systems around Addis Ababa and plan to extend the study to several areas in the country (Alemu Gebre-wold & Azage Tegegne; personal communication, 2000). This study was, therefore, planned to study the urban, peri-urban and rural dairy production systems in the Harari region as part of the national programme.

The broad objective of the study was to characterise the dairy production systems, identify problems and constraints that require research and subsequently would provide options for improving, promoting and developing the Harar milkshed.

The specific objectives of this study in the Harar milkshed were to:

1. Characterise the dairy production systems in terms of the demography, herd structure, genotype of animals, management practices and the main reproductive and productive performances of dairy farms.
2. Characterise the feed resources and identify the most common feeds used, feeding practices and constraints.
3. Assess the relationship between the utilization of the feed resources, liveweight and body condition scores of cows before and after calving and the reproductive performance of milking cows and milk productivity of the farm units in urban areas.
4. Monitor the farm management systems and identify existing shortcomings.
5. Assess milk marketing systems and identify the major constrains of the marketing activities.

CHAPTER 2

MATERIALS AND METHODS

2.1 STUDY AREA

This study was conducted in the Harar milkshed in eastern Ethiopia. This includes two adjacent areas, namely the Harari region and the Babile district from the Oromia region of Ethiopia.

The Harari region is one of nine administrative regions of Ethiopia. It supports a densely populated area located in eastern Ethiopia (Figure 2.1) where crop-livestock, agro-pastoralist and pastoralist farming systems are predominant.

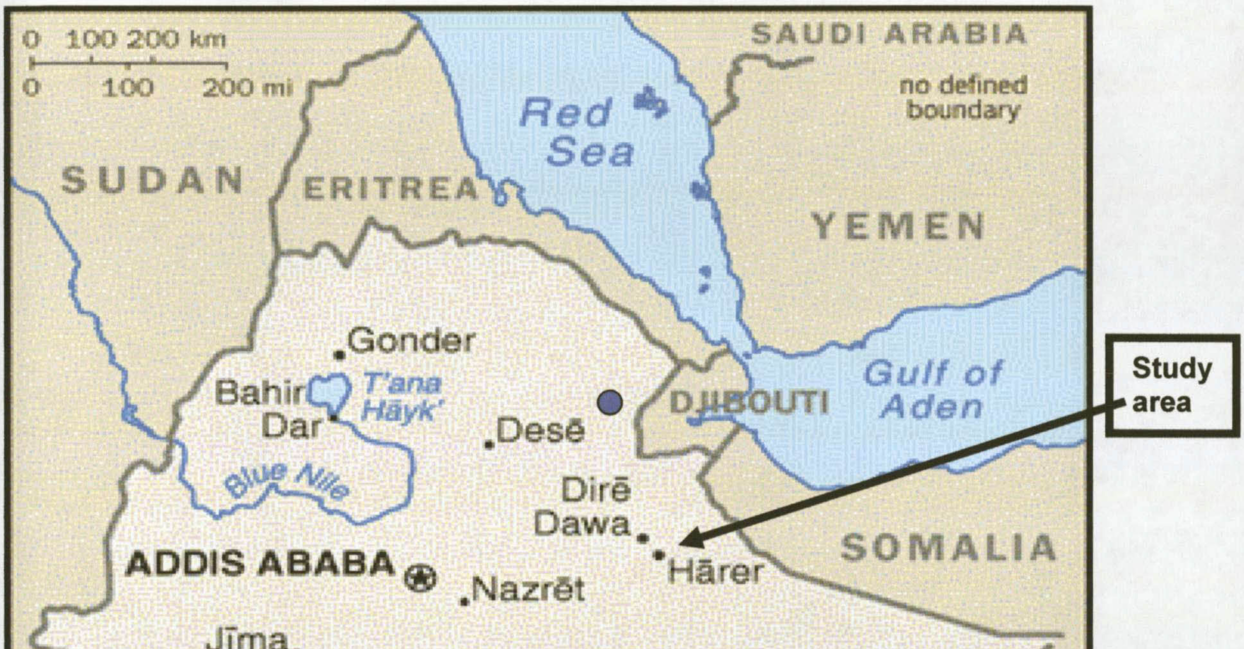


Figure 2.1 **Study area in eastern Ethiopia**

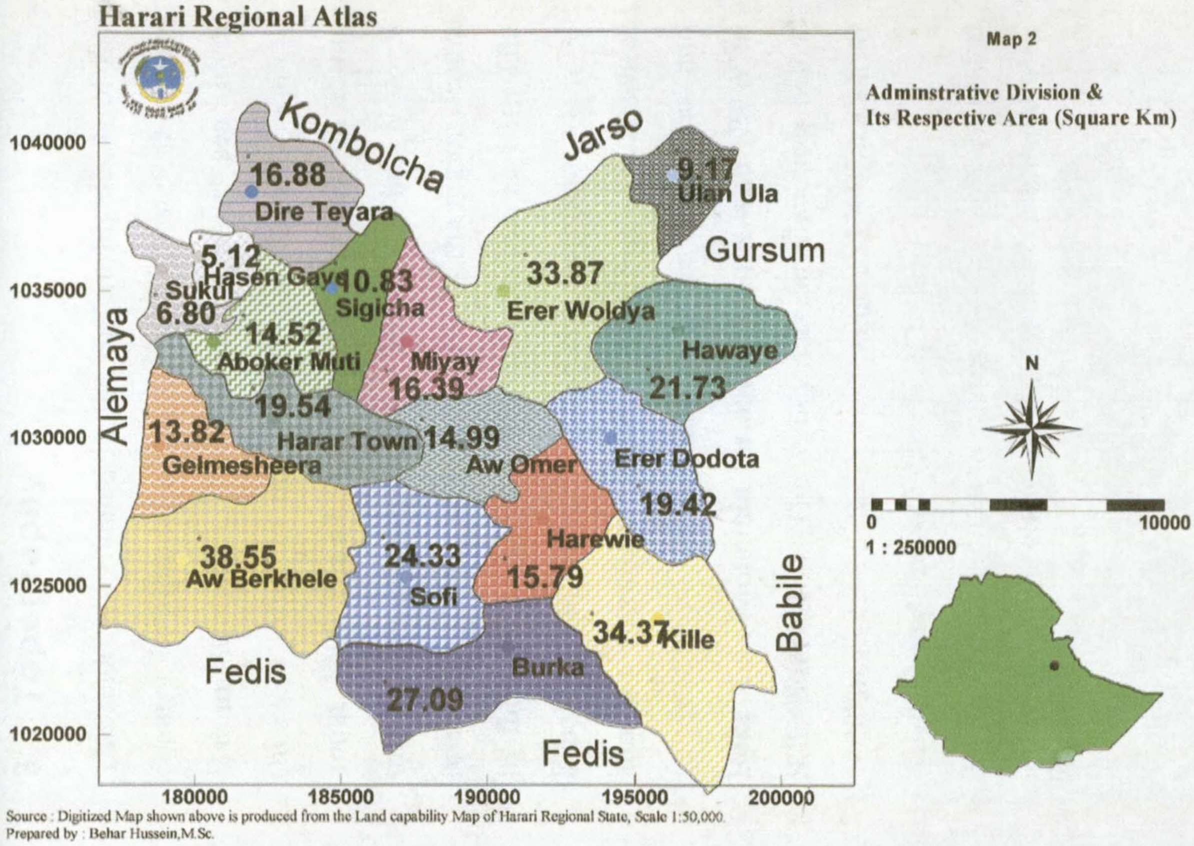


Figure 2.2 Study site, the Harar milkshed in eastern Ethiopia

The Harar milkshed includes the whole Harari region and the Babile district (*warada*) from the bordering Oromia region to the east of Harar. Bisidimo is a small town in the Babile district and is located 18 km southeast of Harar town and 3 km off the main road leading from Harar to the town of Jijiga.

The Babile district and the area around Bisidimo are identified as important components of the Harar milkshed and supply milk to Harar town. The Harari region lies between latitude 9°24'N and 9°42 03E and 42°16'E longitude. The Harar town is situated about 500 km east of Addis Ababa. The Babile district lies between 8°9'N and 9°23'N latitude and 42°15'E and 42°53'E longitude and is about 35 km to the southeast of Harar town.

More than 99% of the population in the Harari region and the Babile district are Muslim and belong to the Harari, Oromo, Argoba and Somali ethnic groups (ECSA, 1999).

2.1.1 The production systems and socio-economic aspects of the Harar milkshed

Most rural households are engaged in agricultural activities that are classified as crop-livestock integrated farming systems or alternatively, livestock-crop production integrated farming systems on the basis of land use systems and the scarcity of land and animals in the study area (Jahnke, 1982). The crop-livestock integrated farming system is predominant in the highlands, while the livestock-crop integrated farming system is dominant in the lowlands.

In terms of market relations, farmers are operating at various levels ranging from predominantly subsistence farmers to market-oriented producers (Dopper, 1991). Based on the relative access to resources and the level of external input procured, these systems are characterised as low external input agriculture, with a shortage of capital and relative abundance of labour. The relatively abundant labour is used to increase or sustain output of crops and livestock from the land (Schiere, 1995). Mixed farming with multiple crops (food and cash crops) and species of livestock is practiced to secure subsistence from the small-holdings.

2.1.2 Climate and cropping calendar

According to the Harari regional atlas (PEDB, 2000) and depending on the altitude, the Harari region is generally classified into two broad traditional agro-ecological zones. The areas above 1 800 m above see level are classified as moderate *weina dega* (middle altitude) and those lying below 1 800 m above see level are classified as dry *kola* (lower altitude). For all practical purposes, however, the term highland is generally used to refer to the landmass at an altitude above 1 500 m, including the valleys (GoE, 1986). Most of these areas receive more than 700 mm rainfall and have a mean daily temperature of about 20°C. The mean monthly minimum and maximum temperatures of Harar are 12°C and 26°C respectively (Figure 2.3). The average amount of annual rainfall received from 1999 to 2002 was 770 mm (Figure 2.4). Unfortunately the rainfall data for Harar was only available from 1999 as opposed to Babile that has an active weather station with data readily available for several years.

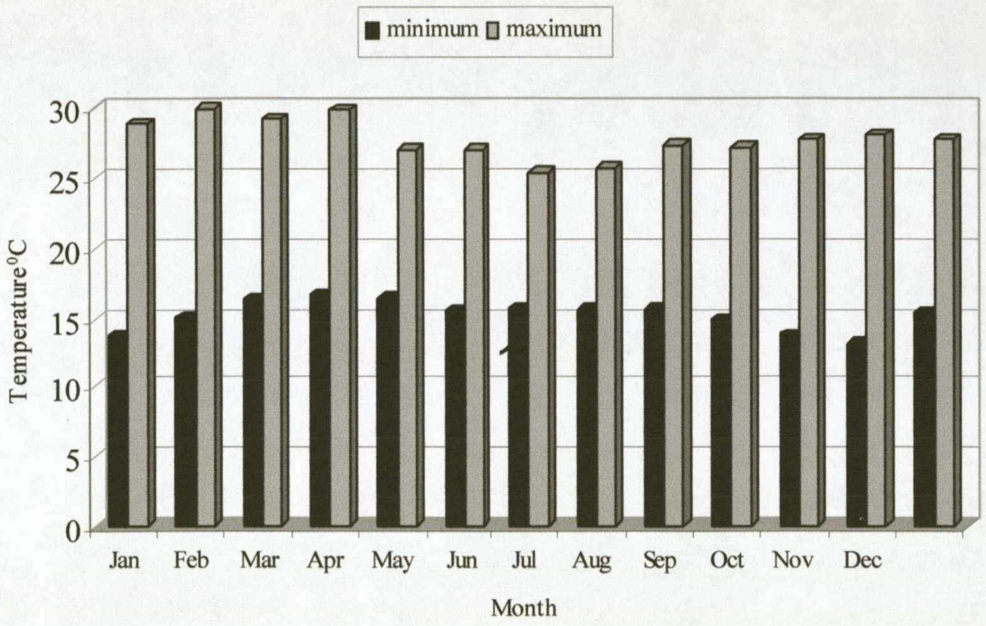


Figure 2.3 **The mean monthly minimum and maximum temperature for Harar between 1999 and 2001 (Source: weather station of Harari region, unpublished)**

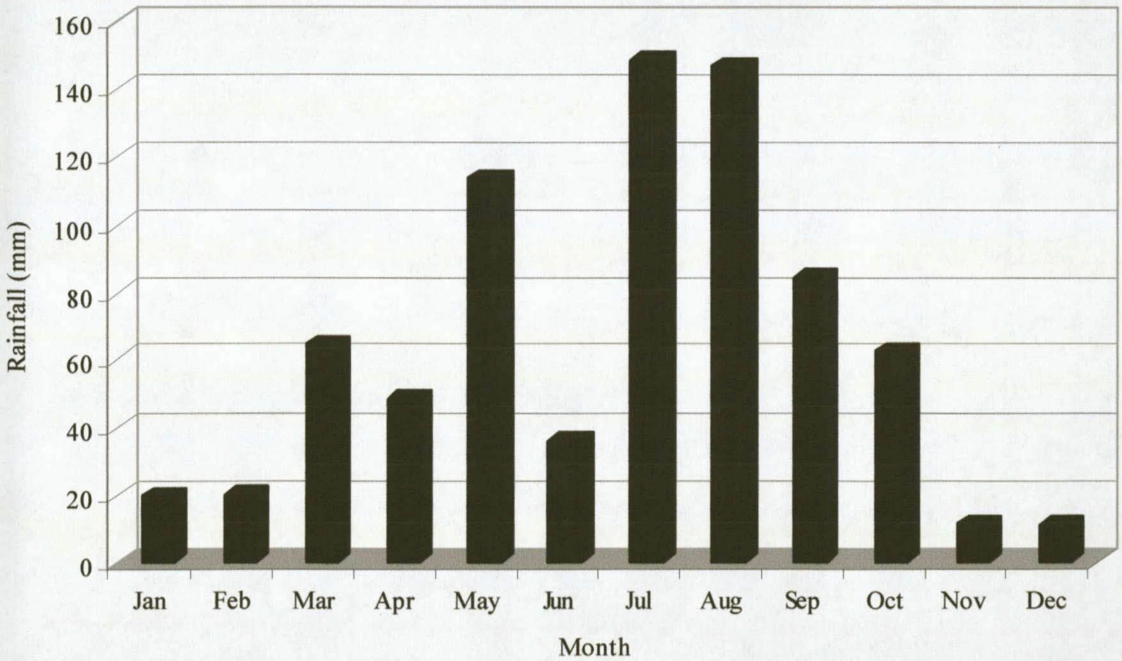


Figure 2.4 **The mean monthly rainfall for Harar between 1999 and 2001 (Source: weather station of Harari region, unpublished)**

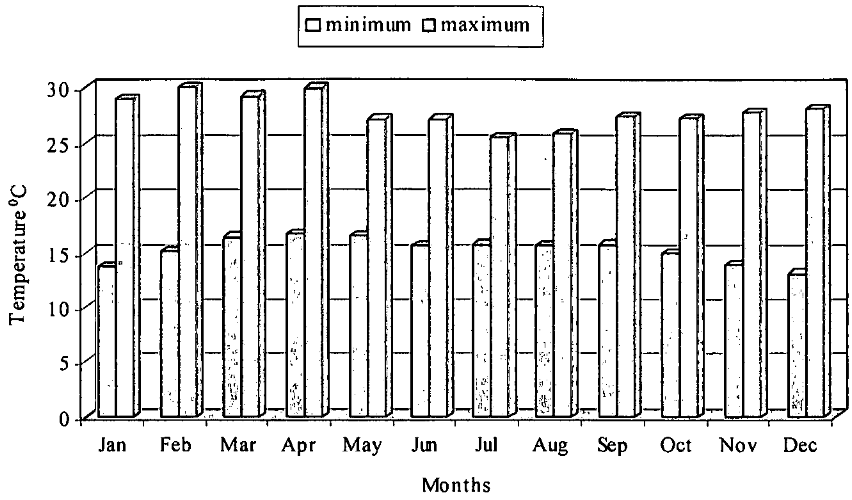


Figure 2.5 The mean monthly minimum and the maximum temperature of Babile between 1997 and 2001 (Source: weather station of Alemaya University, Babile research station, unpublished)

It is generally estimated that the highlands of Ethiopia comprise about 40 to 50% of the total land area of the country (GOE, 1986). The same proportion constitutes the highlands or area at the middle altitudes in the Harari region (PEDB, 2000). For centuries the mild climate has provided an environment conducive to integrated crop-livestock farming operations in the region. In the dry (*kola*) area, accounts for about 60% of the total land of the Harari region at the lower elevations where gentle plains and flat plains are abundant, livestock-crop farming is more dominant.

The Harari region has a wet tropical climate and receives an annual rainfall of between 600 and 900 mm in a bimodal pattern (Figure 2.4). The bimodal pattern is characterised by a short rainy season that occurs between March and April and a long rainy season that occurs between July and September. In the Harari highlands, farmers traditionally have their own agricultural calendar to carry out various activities during the year. Normally, land preparation for the long rainy season (*meher*) crop production, is done in March and planting is done in April. Weeding activities are carried out at the beginning of May at different intervals until the crop is harvested in October and sometimes only in December (Kurtu & Mulat, 1997).

Babile has an altitude ranging between 950 and 2 000 m above sea level. The lowest areas lie at the floor of Dakata valley (950 to 1 600 m above sea level). According to the traditional classification of agro-climatic zones, Babile belongs to the moderate (*weina dega*) and dry (*kola*) agro-climatic zones covering about 15% and 85% of the total area respectively (Zonal DPPD, 1998). The moist (*Dega*) area (1 500 to 2 000 m above see level) is characterised by an average annual rainfall between 600 and 2 000 mm. An average of 715 mm was recorded during the study period (Figure 2.6), with mean monthly minimum and maximum temperatures of 15°C and 20°C respectively (Figure 2.5).

The dry (*kola)* agro-climatic zone at an altitude of 900 to 1 500 m is characterised by an annual rainfall of 410 to 820 mm and mean annual temperatures ranging between 15.5°C and 27.8°C (Figure 2.6).

Babile area has almost the same type of rainfall pattern as Harar and farmers practise a similar agricultural calendar as for the Harari region. The only difference is that while the long rainy season starts in Harari region in July, it usually starts in May in Babile. The average land holding size of arable land per household/family in Babile was about 8.5 ha in 1996/97 (DPPD, 1998). In the Harari highlands this land size is much smaller and less than 1 ha/ household (ECSA, 1999).

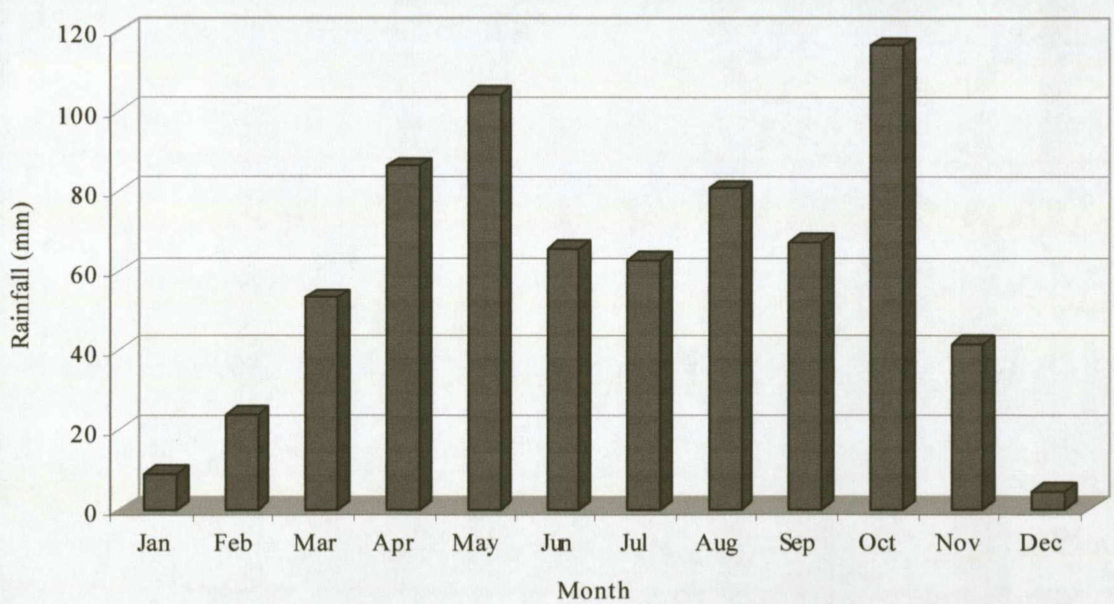


Figure 2.6 **The mean monthly rainfall of Babile between 1997 and 2001 (Source: weather station of Alemaya University, Babile research station, unpublished)**

2.1.3 Soils

According to soil studies, 49% of the region has loam soils with favorable characteristics for plant growth and high stability with a reasonable level of management (PEDB, 2000). To the east of Harar the texture changes gradually to a more course and sandy soil. Most cultivated land is suffering from lack of nutrients, mainly phosphorus. Owing to population pressure on land and expansion of cropping activities, coupled with poor traditional management practices, it is becoming evident that soil depletion is already in progress (ECSA, 1999). Subsequently, nitrogen and organic matter are below the optimum levels and production per unit area is decreasing substantially. In addition, soil erosion is a common phenomenon observed almost everywhere in the region (PEDB, 2000).

2.1.4 Water resources

The Harari region belongs to a micro-watershed, within the Wabi-Shebelle river basin. There are three major annual streams within the micro-watershed, namely the Erer, Bisidimo and Hamaressda (PEDB, 2000). As some historical documents indicate, in the past the Harari region had a large number of perennial streams surrounding the town of Harar that provided sufficient quantities of water for domestic consumption as well as for year round irrigation. However, today, Harar is one of the areas suffering from serious water shortages in the country (PEDB, 2000).

2.1.5 Human population

The size of the human population in the Harari region is presented in Table 2.1. The urban population comprised 60% and the rural population represents 40% of the total population, from which 49% are females. The estimated population growth rate was 3.5% for the region, with 4.2% and 2.5% for urban and rural areas respectively (PEDB, 2000).

2.1.6 Crop production and farming systems

The variation in agro-climatic characteristics, type of soil and the natural vegetation resulted in the development of different socio-economic niches that reflect different farming systems. The farming systems in the Harari region are characterised by complex production units in which different crops are grown in combination with livestock production (Kurtu & Mulat, 1997).

Table 2.1 The human population of the Harari region and the Babile district in 1994*

Location	Urban	Rural	Total
Harari region	93 413	61 681	154 794
Babile district	9 785	4 171	51 496

* Based on the data of 1994 population and housing census for the Harari region (Source: Analytical report of Ethiopia results for Harari region Volume II, 1999)

Various annual and perennial crops are grown, usually in a combination of two or more crops at the same time and in the same plot (inter-cropping) or consecutively/rotationally within a cropping season. The major crops in Babile are sorghum (Germ specie) and groundnuts (Germ specie) accounting for 82.7% of the cultivated land in 1995/96 (DPPD, 1998). Depending on the location, either chat *(Cahta edulis)* or groundnuts are grown as cash crops. Chat (*Cahta edulis*) is a shrub-like plant that has neuro-stimulant properties (its fresh leaves are chewed) and is an important cash crop grown in the region, occupying about 12.8% of the total cultivated land (PEDB, 2000). Some farmers grow a number of vegetables and fruits as a supplementary or main source of income. Harari region has been known for producing a variety of fruits, probably more than anywhere else in the country. The fruits produced include papaya *(Carica papaya),* mango *(Magifera indica),* bull-heart or black-heart *(Annona cherimola),* to mention only a few. There are also exotic fruits, like *hangora (Macatamia tetraphylla*), and *woshmalla (Eribotrya Japonica*), which are known to be special to the region (PEDB, 2000).

2.1.7 Forests and wildlife

After large areas of the natural forests have been destroyed only very few and small natural forest areas are left, covering only 1-2% of the region (DPPD, 1998). The forestland contains natural vegetation such as *wayra* (*Olia Africana*), *warka* (*Ficus su*) and *wanza* (*Cordia Africana*) to name only a few. *Qulqal* (*Euphorbia tirucalli*) and *kinchib* (*Euhporbia cantelabrum*) are planted as natural fences on farmland. Thus, the Harari region is one of the administrative regions in the country that is suffering from high environmental degradation (PEDB, 2000).

The region has a variety of wildlife that includes the spotted hyaena (*Crocuta*

crocuta), the mongoose (*Galerella pulverolenta*), the serval cat (*Felis serval*), the warthog (*Phacochoerus aethiopicus*), rabbits (*Pronolagus spp*), lion (*Panthera leo*), duiker (*Sylvicapra grimmia*), elephant (*Loxodonta africana*), common baboon (*Papio ursinus*) and squirrel (*Xerus inauris*). Wildlife is a major tourist attraction in the region and an important source of income to the local economy.

Babile district has a very limited forest area, consisting of woodland savanna, acacia woodland bushes, shrub grassland and man-made forests. Currently only about 3.7% of the area is covered by forest (DPPD, 1998). There is a wildlife conservation sanctuary known as the Erer Wildlife Sanctuary close to Babile town. The animals in the sanctuary include, among others lions (*Panthera leo*), hares (*Lepus saxatilis*) and a few kudu (*Tragelaphus strepsiceros)* (DPPD, 1998). According to some farmers certain wild animals, especially lions, sometimes pose a threat to livestock reared in the area.

2.1.8 Livestock production

Livestock is an important component of the integrated crop-livestock production systems in the Harari region as well as in the Babile district where it is common to keep a small number of cattle, goats and sheep. There are also more donkeys and chickens in the highlands compared to the lowlands. These livestock species are kept for various purposes and have different priorities in the different production systems. The livestock population in rural areas of the Harari region is estimated at 28 082, 3 047 and 15 099 head of cattle, sheep and goats respectively (DPPD, 1998; PEDB, 2000). Cattle comprise 55% of the total livestock population. An estimated 3 583 donkeys and 630 camels were in the region in 1998/99 with a poultry population of 24 668 (ECSA, 1999). The poultry production is based on a traditional backyard type of production, which normally does not exceed ten birds per household. The birds roam free and survive by scavenging. In the Babile district the livestock and poultry populations appear to be larger than in the Harari region, but the exact numbers are not available mainly because no census has been recently done in this area. However, estimates according to ECSA (1995) were 57 301 cattle, 2 331 sheep and 1 252 goats. Of the non-ruminants, there were at that time 1 436 donkeys, 5 774 camels and 10 454 chickens. Cattle are kept as multiple purpose animals that include milk and meat production, as sources of draught power, manure and other socio-economic functions.

2.1.9 Livestock feeds

There are very small grazing areas in most parts of the highlands in the Harari region and a cut-and-carry system is a common feature in most rural areas. Crop residues, thinnings from sorghum and maize, and weeds are major feed resources for ruminants where crops are produced. While crop residues are used during the dry season after harvesting, thinnings and weeds are generally available during the wet season. Concentrate supplementation is rarely practiced in the rural areas. In urban areas, however, crop residues, conserved hay and some weeds and forages are fed on a cut-and-carry basis and concentrate supplementation is more common (PEDB, 2000).

Babile district has a relatively large grazing area but with a low biomass production or low carrying capacity of 3-5 ha/Tropical Livestock Unit (TLU). A TLU is equivalent to a head of mature cattle of 250 kg live weight (ECSA, 1999). Crop residues (sorghum and maize) are major feed resources used to supplement the natural pastures in the area (DPPD, 1998).

2.1.10 Agricultural extension and veterinary services

Development oriented extension activities, both at the national and regional levels in Ethiopia, seem to be focusing on crop production. As a result the agricultural development programs are usually addressing crop issues and little attention is given to livestock production. In the Harari region, there have been very few activities focusing on livestock production by way of addressing dairy production through the Agricultural Bureau. The main activities of the Agricultural Bureau are limited to some veterinary activities i.e. vaccination campaigns against the most common livestock diseases and artificial insemination (AI) services in urban areas. Currently, there are five animal health centers in the Harar milkshed that include animal health clinics and health posts at various places in the region. Two of these clinics are located in Harar town and the remaining three are distributed in different parts of the rural areas. These animal health centers offer services to all livestock owners in the region. The main services they render include assessment of disease conditions, treatment of sick animals and vaccination against various contagious diseases. The AI services are limited to market oriented dairy farms, adopting more improved management practices and farming with upgraded genotypes (Holstein crossbred cattle) in and around the town.

2.2 THE SURVEY

In this part of the study a questionnaire-based survey was conducted in the Harari region and Babile district as a method of gathering relevant information on the Harari milkshed. Two hundred rural households and 50 urban households were involved in this survey. These households were actively involved in dairy production at the time of the survey or have discontinued dairy production within two years from the time of the survey. These households were chosen in terms of milk production potential, cattle population and market access (distance from Harar town and/or local market) as judged by expert key informants.

2.2.1 Questionnaire development

The questionnaire was developed using empirical knowledge of the author and inputs from other animal science specialists (e.g. Mr. Yousef Mekasha & Dr. Azage Tegegne) who have been working in the Addis Ababa milkshed. Questionnaires used by these specialists in previous studies were also consulted. The local Agricultural Bureau and the farmers were involved in the design of the questionnaire as well. This questionnaire was pre-tested and the numerators trained before the questionnaire was applied at field level. The questionnaire was modified according to the experience gained during the testing phase and expanded to incorporate data needs of the collaborators. The questionnaire was divided into sections covering: household demography; labour availability and use; farm activities and facilities; livestock inventory; cattle feeding; management practices (distinguishing between purchased and self-produced feedstuffs); dairy cattle performance (with emphasis on milk production); milk processing; milk marketing; livestock management and health services; consumption and sales; milk co-operative membership and delivery systems.

2.2.2 Participatory rapid rural appraisal

Information relevant to the historical perspective, people's perception, production levels, management practices, consumption, utilization, handling, processing and marketing of milk and milk products including traditional and improved methods used, were also collected. The information gathering was based on the methodologies of Participatory Rapid Rural Appraisal (PRRA) and Rapid Appraisal of Agricultural Knowledge System (RAAKS) (Sands, 1985; Dura & McMillan, 1992). Small groups of farmers were interviewed at their homesteads to allow them to be involved in problem identification and the designing of possible solutions to the existing constraints limiting the dairy production in the area.

For detailed information and data collection on various aspects of agricultural practices relevant to dairy production, a structured questionnaire was developed (M.Y. Kurtu, 2003; unpublished data) and interviews conducted with farmers. A second questionnaire (M.Y. Kurtu, 2003; unpublished data) was obtained from the veterinarian in the Harar milkshed and was used to access the epidemiological status of the herds.

Group discussions with rural communities (small-scale farmers in the rural areas) and with the dairy business groups in urban areas were held in the study area. Through networking, specialists on the same topic (e.g. Mr. Yousef Mekasha & Dr. Azage Tegegne) who have been working in the Addis Ababa milkshed area were consulted to gather relevant information using the RAAKS methodology, shared problems were defined, constraints and opportunities for diary production were analysed.

Farmer's perceptions, management practices, constraints, opportunities and innovations were analysed and these served as the basis for the second phase or component of this study (monitoring of urban dairy systems). Exploratory surveys, direct observations, unrestricted interviews and interviews with key informants (development agents, livestock specialists, etc.) were undertaken where greater emphasis was placed on farmers' participation in rural development according to Chambers (1992) and subsequently, the urban dairy production systems were defined. Estimates of annual milk production and resource utilization as well as major constraints were identified.

2.2.3 Selection of households and farmers' associations

Representative sites within the Harar milkshed in terms of milk production potential, cattle population and market access (distance from Harar town and/or local market) as judged by expert informants, were chosen. There were only two districts (*waradas*) of the Harar milkshed involved in the study, namely Hundane in the Harari region and Babile in the Oromia region. It was then decided to select farmers' associations (FA) from Harari/Hundane and from Babile/Oromia that would be representative of the dairy production systems within each of the two districts. Six divisions/farmers' associations from Hundane and four from Babile were selected to reflect the diversity of agro-climatic zones and variation in production systems. In total 10 farmers' associations and 200 rural households in the two districts and 50 urban households (dairy farms) from urban and peri-urban areas were selected. More farmers' associations were included from the Harari/Hudene region than from Babile/Oromia as they represent the major production centers within the Harar milkshed.

Prospective farmers' associations were grouped according to a combination of milk production potential and market access into High-High, High-Medium, High-Low, Medium-High, Medium-Medium and Medium-Low respectively (Table 2.2). The sub-locations were selected randomly from pre-selected districts and divisions/farmers' associations on the basis of their potential for milk production in such a way that all low, medium and high potential areas were covered. This was accomplished by involving key informants from the regional Agricultural Bureau, extension workers and dairy farmers in the Harar milkshed. Twenty households/dairy farmers were surveyed from each of the 10 farmers' associations. The regional Bureau of Agriculture, extension workers within the Ministry of Agriculture of the region and staff at district *(wereda)* levels, have taken part in the course of the survey.

Table 2.2 The farmers' associations (FAS) grouped according to milk production potential and access to markets

Milk production potential	Access to market	District/farmers' associations
High	High	Harar-Urban dairy
	High	Galmahsira/Harari region
	Medium	Deretayara/Harari region
Medium	Low	Ifadin/Oromia region
	Medium	Burka/Harari region
	Low	Anood/Oromia region
	Medium	Awberkele/Harari region
Low	Low	Awsharif/Oromia region
	Medium	Erer/Harari region
	Medium	Kile/Harari region
	Low	Berkele/Oromia region

The information obtained from the Harari regional Atlas (EDPB, 2000) and the key informants involved in the survey were used to make the groupings of production systems in different agro-climatic zones. These were: sorghum-cattle (dairy); sorghum-chat-cattle (dairy); and sorghum-groundnut-cattle (dairy). The livestock-crop system is usually dominant in lowlands where moisture is a constraining factor for crop farming; these are cattle (dairy)-sorghum and camel (dairy) cattle (dairy)-sorghum (Table 2.3).

Table 2.3 The farmers' associations (FAS) targeted in the survey and the predominant land use systems

District (*Wereda*)	Farmers' Association*	Farming systems**
Hundane (Harari)	Awberkale	Sorghum-chat-and-cattle
	Deretayara	Sorghum-chat-and-cattle (dairy)
	Erer	Sorghum-cattle (dairy)
	Galmashira	Sorghum-chat-and-cattle (dairy)
	Kile	Sorghum-groundnut-cattle (dairy)
	Burka	Sorghum-groundnut-cattle (dairy)
Harar town	Urban	Dairy
Babile (Oromia)	Berkale	Cattle (dairy)-Camel (dairy)-Sorghum
	Anood	Cattle (dairy)-Camel (dairy)-Sorghum
	Awsharif	Cattle (dairy)-Camel (dairy)-Sorghum
	Ifadin	Cattle (dairy)-Camel (dairy)-Sorghum

* Farmers Associations (FAS) = lowest administrative units covering villages within 800 km^2 of the rural area.

** Names of the farming system are given in order of dominance.

2.2.4 Questionnaire based survey

The questionnaires were completed at the household and in the farmers homestead during individual interviews with the household head, or in his/her absence, with the most senior member of the household available or the household member responsible for the farm.

Enumerators were selected among the front-line extension staff of the Ministry of Agriculture (MOA) in each district or farmers' association. A supervisor (researcher) checked each completed questionnaire in order to ensure that the information was as accurate as possible. Descriptive statistical analysis was carried out using procedures of SAS (1989).

2.2.5 Data collection during the survey

The diagnostic survey included aspects such as data on household characteristics, herd size and structure per farmer/household, genotype, management practices and productivity of the animals. Information on feed resource availability, feeding practices and reproductive parameters were collected from the farms. Information on animal health and hygiene, housing and incidences of the most important diseases was collected with the assistance of local veterinarians. The survey was conducted between January 2001 and January 2002.

2.3 HERD EVALUATION AND MONITORING

In a second phase of this study a number of selected herds were evaluated and monitored. Based on the results of the 1st phase of the study during the preceding survey and the number of different categories of dairy farms, a sample size was determined for this second part of the study. Thus, 26 diary farms consisting of three large, seven medium and 16 small urban and peri-urban diary farms in and around Harar were selected for this second phase of the study (Table 2.4).

Table 2.4 Number and size categories of the 26 urban dairy farms selected for herd evaluation and monitoring

Farm size category	Number of dairy farms
Small dairy farms	16
Medium dairy farms	7
Large dairy farms	3
Total	26

2.3.1 Herd composition

All cattle on each of the 26 selected farms were identified with ear tags. A herd inventory was drawn up for each farm at the beginning of the monitoring phase. The herd composition in terms of breed, sex, age, class and related detail were recorded.

The number of lactating cows, stage of lactation and lactation number were obtained from either the survey work or from available farm records. The herd size and composition was calculated from the monthly inventory records.

2.3.2 Description and quantification of feed resources

All feedstuffs used for the dairy animals were described and were quantified. The amount of hay produced and/or purchased was estimated by using the farm records, questioning of the farmers, estimating the land size, using information from literature and empirical knowledge for estimating yields. The amount of crop residues produced at the farm was estimated by applying a grain:straw ratio of 1:0.6 (Anderson, 1987). Information on concentrates and other purchased feedstuffs including minerals were gathered from the structured questionnaire and obtained or confirmed during the monitoring at farm level.

2.3.3 Monitoring feed utilization and the nutritive value of the feeds

Monitoring of feed utilization was carried out on a monthly basis on all 26 selected dairy farms. The data included feed intake and milk yield estimates on the specific day of the visit and these estimates were used to calculate the values for the month.

2.3.3.1 Determination of feed intake and milk produced

Daily feed allowance and the left over were measured and the difference was taken as feed intake. Daily feed allowance and left over were recorded. The difference between the feed offered and refusal records was taken as feed intake for each animal or groups of animals per day during the monitoring period. Dry matter intake (excluding intake from pasture) was estimated for a period of one year for the different groups of animals.

Milk produced at each of the 26 farms were measured using a graduated measuring cylinder and recorded for individual animals at both morning and evening milking; the sum of which was recorded as the daily individual yield.

2.3.3.2 Determination of nutritional value of feeds

Samples of the most commonly used feedstuffs for dairy cattle were collected and analysed in the laboratory to determine its nutrient content.

2.3.3.3 Determination of the nutrient availability

The metabolizable energy (ME) of individual feeds was estimated based on the results from the laboratory analysis and values published in the literature.

The total ME and nitrogen (N) intake were derived from the estimates for the entire period by summing the amount of each feed multiplied by the respective ME and crude protein (CP) values (CP = %N x 6.25).

Similarly, the amount of some minerals, i.e. phosphorus (P) and calcium (Ca) were estimated from the laboratory results of individual feed analysis and feed intake information.

2.3.4 Laboratory analysis of feeds

A total of 11 different feeds were identified and sampled for laboratory analysis. These feed samples included four forages (grass hay, green grass, green maize and elephant grass), two crop residues (sorghum stover and groundnut hulls), four agro-industrial by-products (wheat bran, groundnut cake, industrial brewery waste and local brewery waste) and flour mill waste. Samples from daily feed allowances provided to individual or groups of animals were drawn on a monthly basis during the monitoring period and were pooled. Sub-samples were taken form the pooled samples for laboratory analysis.

In addition to the collecting of forage samples, especially elephant grass (*Pennisetum purpureum)*, samples were also collected from the production sites for quantitative and qualitative evaluations. Samples from brewery by-products per batch from brewery factories were collected and were pooled. Sub-samples were taken from the pooled samples for laboratory analysis.

The samples were stored in airtight plastic bags before being sent to the laboratory for analysis. Samples were dried at 60°C for 72 hours using a forced draught oven. Dried samples were ground to pass through a 1 mm sieve before used for the subsequent analysis. Forage and feed samples were analyzed for dry matter (DM), crude protein (CP) and ash content (AOAC, 1980). For nitrogen (N) determination the Kjeldahl procedure was used (AOAC, 1980). *In vitro* organic matter digestibility (IVOMD) was determined with the modified procedure of Tilley & Terry (1963) as outlined by Goering & Van Soest (1970). Metabolizable energy (ME) concentration of each feed was estimated from *in vitro* digestibility values as suggested by AOAC (1980) namely, ME (MJ) = 0.17 x IVOMD% - 2. Calcium (Ca) and phosphorus (P) content were determined with an atomic absorption spectrophotometer and auto-analyzer, using ascorbic acid as reducing agent (Perkins, 1982).

2.3.5 Determination of milk production

Milk produced at each of the 26 farms were measured using a graduated measuring cylinder and recorded for individual animals at both morning and evening milking; the sum of which was recorded as the daily individual yield per cow. The total daily milk production was also calculated for each herd. This was done once a month during the monitoring period by the resident enumerators.

2.3.6 Monitoring reproductive performance

Recently calved cows were selected from the herd at each site to monitor the reproductive performance of post partum dairy cows. Cows were monitored from the fourth day of lactation until the cows were confirmed pregnant by an AI technician by means of rectal palpation. During the one year observation period for the 26 herds the following parameters were monitored to estimate the effect of season:

- ***Number of services/conception:*** The number of services required and type of mating (natural or AI) practiced until the cows were confirmed pregnant, were recorded. Pregnancy diagnoses were performed by an experienced operator 60 to 90 days after the last service by means of rectal examination.

- ***Body weight and condition score fluctuations:*** Body weights were estimated with the aid of a heart girth measuring tape and were applied to estimate body weight 30 days before and 30 days after calving. The tape is produced in Denmark and provides a body measurement (circumference of heart girth in cm) from which the body mass or weight (kg) of cattle can be estimated. A Tropical

Livestock Unit (TLU) is equivalent to a mature head of cattle of 250 kg live weight (ILCA, 1993). The number of TLU's were calculated for each herd. Body condition scores on a scale of 1-5 (Wildman *et al.*, 1982) were determined concurrently with the live weight estimates of the cows. Important steps to be considered include the line from the book to the thurl, whether the pin bone is angular or crescent bone, if the sacral and tail head ligaments were visible, if the thurl is flat and short bones were visible.

2.4 A BRIEF DESCRIPTION OF THE TERMINOLOGY USED

In order to facilitate a good understanding of the next sections of this thesis it is important to define some terms in the context of this study.

The term milkshed refers to the geographical areas where milk is produced and marketed in a specific consumer centre, in this case, the Harar town. It is analogous to a watershed.

The term urban farmers refers to dairy farmers in urban or peri-urban areas within the Harar milkshed. Rural farmers refer to the farmers in the rural areas within the same milkshed.

The term household describes a production unit, most commonly a family, urban or rural that was engaged in milk production in the Harar milkshed at the time of the survey or has been involved in this activity in the recent past (up to two years). Six of the production units from the 50 urban dairies included in the survey were institutions (orphanages, old age home and schools). For the purpose of this study these institutions were considered as households. These six dairies were used for the monitoring phase, but for obvious reasons excluded from the socio-economic part of the study. Households were classified as non-agriculturist if at the time of the survey they did not derive any income or produced any agricultural product (milk or any other). The head of the household was the person interviewed and he/she was considered a farmer if the household was agriculturist. Depending on the proportion of total income generated by the household, he/she was called a part-time farmer, if most of the income was generated from non-agricultural or off-farm activities. Farmers on the other hand derived the larger part of the household income from agricultural activities.

Small-scale dairy farmers produce milk mainly for household consumption and may also sell their excess production. Commercially oriented dairy farmers produce milk mainly for a market.

2.5 DATA ANALYSIS

Analysis of variance and mean comparisons were done using SAS procedures (SAS, 1989). Principal component analysis and the cluster analysis and the X^2-test were performed using procedures of SPSS (1999). A more detailed description of the statistical procedures used specifically for each part of the study is presented in the respective chapter (when applicable).

CHAPTER 3

CHARACTERISATION OF DAIRY PRODUCTION SYSTEMS IN THE HARAR MILKSHED

3.1 INTRODUCTION

Dairy farmers on smallholdings produce more than 50% of the total milk consumed in Ethiopia and more than 90% of the total fresh milk marketed (Abaye *et al.,* 1989). Milk production systems vary widely in terms of the breeds, intensity of land and labour use and feeding practices. The recently introduced market liberalisation policies in Ethiopia seem to have given new impetus for the increased off-take of milk by improving opportunities for dairy co-operatives and private entrepreneurs to market dairy products (Staal *et al.,* 1997). As a result, changes are apparent in milk production and marketing in various regions of the country, including the Harar milkshed. Yet, little is known about this pattern of change and its effects on the dairy production systems. Very little is also known about small-scale farmers, in particular about the small-scale dairies operating under different production conditions. In this regard the concern is shared by the governmental and non-governmental organisations who are dealing with various development strategies particularly rural development policies that focus on small-scale dairy farmers.

A comprehensive study was initiated by the International Livestock Research Institute (ILRI) to characterise small-scale dairy production systems in the Addis Ababa milkshed. The aim was to characterise and identify constraints and opportunities in dairy related activities in the Addis Ababa milkshed. Similar studies were also planned by the Ethiopian Agricultural Research Organisation (EARO) to be undertaken in various parts of the country under a national research programme. The Harar milkshed was not included in the program, therefore, the present study was conducted in the Harar milkshed within the conceptual framework of the ILRI study plan as developed by Rey *et al.* (1993). According to this framework, a "dairy system" incorporates all production systems and the marketing channels for delivering dairy products to consumers in urban centres, including the policy environment. In this conceptual framework, a study site is defined by a consumer centre, with its milkshed as a production system that includes milk production, processing and marketing, all linked together within the system. In the present study of characterising the Harar milkshed, the consumer centre is the Harar town. The other districts (*weredas*) and farmers associations (FAS) surrounding it and which is providing it with milk, represent the Harar milkshed.

3.2 MATERIALS AND METHODS

Participatory Rapid Rural Appraisal (PRRA) techniques and a structured questionnaire were the major tools used to collect the data during the survey phase of the study. Details and procedures are given in Chapter 2 and the questionnaire is presented in Annexure 1. A survey was conducted among of 250 households of which 200 were from rural areas and 50 from urban areas within the Harar milkshed (for a description of the terminology used in this study, see section 2.4). Simple summary statistics (i.e. frequency distribution, percentage, average, etc.) were used to describe the data.

3.3 RESULTS AND DISCUSSION

A selection of aspects discussed in this study is shown in Chapter 9 (Compilation of photographs).

3.3.1 The types of households in the Harar milkshed

The basic characteristics of the households that were surveyed in the Harar milkshed are presented in Table 3.1.

Table 3.1 Proportion of households engaged in rural and urban dairy production in the Harar milkshed

Location	Number of households interviewed	Number of households with cattle	No farm land	Part-time farming	Full-time farming
Rural	200	191	17	24	176*
Urban	50	50	43	42	8

*Number of rural households dependent on both crop farming as well as dairy production.

Almost all the rural households surveyed in the Harar milkshed were engaged in agricultural activities and most households (96%) were actively involved in milk production. From these, 92% were full-time engaged in dairy production.

In the urban and peri-urban dairy operations, results from the survey indicated that the majority of the households (84%) were engaged part-time as dairy farmers. Being engaged primarily in other business, they regarded dairy production as a side-line type of business and thus an extra source of income.

3.3.2 Household head gender and education level

The head of a household was defined as the person most involved with agricultural activities and who makes the day to day decisions concerning food, expenditure and farming activities. In Figures 3.1 and 3.2 the gender distribution of rural and urban household heads are presented respectively.

On average about 75% of the farming households is headed by males and was very similar for both urban and rural households (Figures 3.1 and 3.2). This compares closely to the situation in Kenya where 28% households are headed by women (Staal *et al.*, 2001). There was no clear indication for differences in the gender proportions of household heads among the different farmers' associations (FAS).

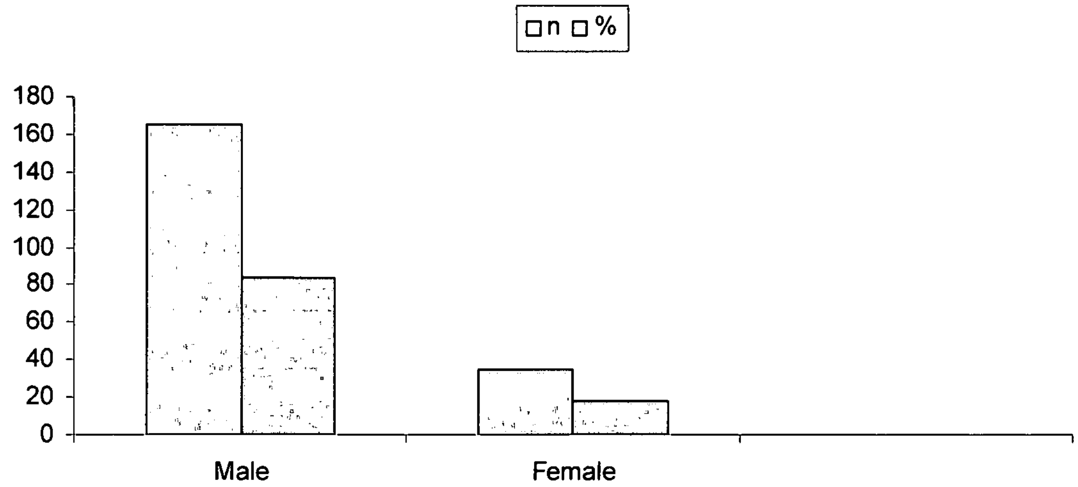


Figure 3.1 **Gender distribution of the heads of the 200 rural households surveyed in the Harar milkshed**

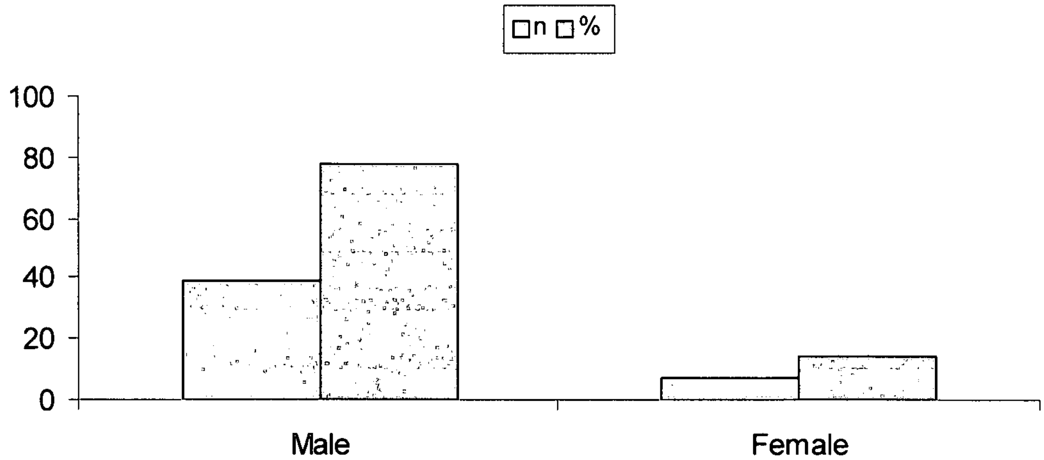


Figure 3.2 **Gender distribution of the heads of the 50 urban and peri-urban households surveyed in the Harar milkshed**

As was to be expected the education level of the household heads in the rural areas did not differ much between the different FAS. In all districts and FAS the education levels were almost the same, namely about 29% were able to write and read and the mean age of the household head was 45 years (Table 3.2). In the urban areas, however, there was variation in the education level of the household (Figure 3.3). The majority of the households in the urban areas (35%) were able to read and write, 24% had post high-school education and the mean age of the household head was 53 years (Table 3.2). Ten of the households were institutions (such as orphanages, schools and hospitals for old people) engaged in dairy production. These do not have a formal defined household head and therefore, were excluded form this analysis.

Table 3.2 **Mean age and level of education of the household heads in the Harar milkshed**

Household	Number	Age	Number illiterate	Number R & W*	Complete elementary school	Complete high school	Diploma	Others
Rural	200	45	144	57	0	0	0	0
Urban**	46	53	1	160	11	12	3	3

* R & W = Able to read and write.

** Four institutions involved in dairy production were not included in this analysis.

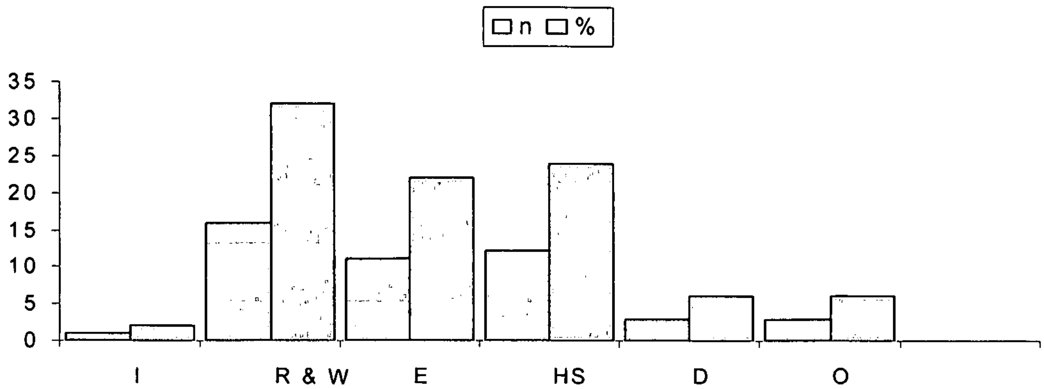


Figure 3.3 **Education levels of household heads in the urban areas of the Harar milkshed Key: I =illiterate; R&W= read and write; E=Elementary school; HS=High School; D=Diploma; O=others (four institutions operating dairy farms are not shown)**

Respondents were also asked to state the main activity of the household head. Among other things, this question was particularly aimed at obtaining information on the off-farm employment opportunities for the household head. It was important to determine if dairy farming was a full-time or part-time activity.

The proportion of household heads whose primary activity was mainly agricultural, is shown in Table 3.3. In the case of 88.5% of the rural households, farming activities were the primary business and only 11.5% were engaged in part-time farming and primarily engaged in other business activities. These activities included trading with agricultural goods from the village to the nearby town and services. On the contrary, 86% of the urban households were part-time farmers, whose major source of income was off-farm businesses such as hotels, flour mills, grain stores and civil and military services.

3.3.3 Size and composition of households

The average household size (Table 3.4) for the rural areas was 7.20 (±3.2) persons composed of approximately 2 persons in the age group 15 to 25 and 4 persons in the age group 26 to 55 years. The other groupings of less than 8 years and over 65 years had 0.8 and 0.22 persons respectively. These numbers varied across locations indicating that the largest households were found in the Anood FAS and the smallest in the Kile FAS. In the rural setting, household size is generally believed to influence labour availability for farm activities, namely for crop as well as livestock production. A small family size may indicate low rural employment opportunities, leading to migration from the rural to the urban environment. The corresponding values for the urban area were lower than for the rural areas, namely 4.8 persons composed of 1.4 persons in the age group of 15 to 25 and 2.6 persons in the age group 26 to 55 years.

Table 3.3 Proportion of rural and urban household heads with off-farm businesses in the Harar milkshed

Location	n	%
Urban	50	86.0
Rural	200	11.5
Highland		
Awberkele	20	15.0
Deretayara	20	10.0
Erer	20	25.0
Lowland		
Anood	20	0.0
Awsherif	20	0.0
Berkale	20	0.0
Burka	20	20.0
Galmashira	20	10.0
Ifadin	20	15.0
Kile	20	20.0

3.4 FARMING RESOURCES

Farm holdings in this study refer to the farm resources that include land, livestock and labour availability to the household. The availability of these resources and how they are being used by the households are described in the following sections.

3.4.1 Land use and cropping practices

It was attempted with the survey to quantify the production of cash and food crops, including sorghum, maize, groundnut and crop residues with importance as animal feed, as well as identifying interactions with dairy production (Table 3.5).

Table 3.4 The size of the household and age composition (mean ±sd) in the Harar milkshed

	Number of persons in each age group category				
Location	8	15-25	26-55	>55	Total
Urban	0.8 ± 1.0	1.4 ± 0.6	2.6 ± 0.9	0.2 ± 0.2	4.8 ± 1.1
Rural	0.8	2.1 ± 1.0	4.0 ± 1.4	0.2 ± 0.5	7.4 ± 1.9
Highland					
Awberkele	0.7 ± 1.1	2.0 ± 1.6	3.7 ± 1.5	0·0 ± 0.6	6.7 ± 2.0
Deretayara	0.7 ± 1.7	2.0 ± 1.0	3.7 ± 1.3	0.2 ± 0.5	6.7 ± 1.6
Galmashira	0.6 ± 1.7	0.6 ± 0.6	3.2 ± 0.8	0.2 ± 0.5	5.8 ± 1.9
Lowland					
Anood	1.4 ± 1.0	3.9 ± 2.3	7.1 ± 2.4	0.4 ± 0.6	12.6 ± 3.8
Awsharif	1.3 ± 1.2	3.4 ± 0.9	6.3 ± 2.1	0.3 ± 0.7	11.4 ± 1.7
Berkale	0.7 ± 1.1	1.9 ± 0.2	3.6 ± 1.5	0.2 ± 0.3	6.5 ± 1.6
Burka	0.6 ± 1.1	1.6 ± 0.3	3.1 ± 1.2	0.2 ± 0.6	5.6 ± 1.8
Erer	0·8 ± 1.7	2.0 ± 1.0	3.8 ± 1.4	0.2 ± 0.6	6.8 ± 1.1
Ifadin	0.7 ± 1.6	2.0 ± 1.3	3.6 ± 0.9	0.2 ± 0.5	6.5 ± 1.8
Kile	0·7 ± 1.5	1.8 ± 0.8	3.3 ± 0.7	0.2 ± 0.2	5.9 ± 2.0

In the rural areas of the Harar milkshed, mean size of crop land was 3.41 ha, with the larger farms of about 6 ha in the Anood, Berkala and Awsharif FAS in the lowlands (Babile district of the Oromia region). The smaller crop lands were in the highland of the Harari region, namely the Galmashira, Deretayara and Awberkale FAS with 1.1, 1.36 and 1.18 ha/household respectively. The mean size of land holding in the Oromia region of the Harar milkshed is much larger than the average holding of the Harari region and surrounding highlands, which is estimated at about 0.5 ha (Ayalew, 1998). This might be as a result of inclinations of the sample of the household towards cattle owners.

In the rural areas sorghum constituted about 1.45 ha of the total crop land of the households and groundnut about 0.75 ha, maize 0.49 ha maize and chat 0.34 chat ha (Table 3.5).

Table 3.5 Size (ha) (mean ±sd) of food crops, cash crops and pasture land in the rural area of the Harar milkshed

Location	Number of households	Grazing land	Crop land	Sorghum	Maize	Groundnut	Chat
Rural	200	1.4 ± 0.6	3.4 ± 1.4	1.5 ± 0.7	0.5 ± 0.8	0.7 ± 0.6	0.3 ± 0.7
Highland							
Awberkale	20	0	1.2 ± 0.7	0.8 ± 0.5	0.1 ± 0.2	0	0.3 ± 0.3
Deretayara	20	0	1.4 ± 1.0	1.0 ± 0.8	0.6 ± 0.2	0	0.4 ± 0.1
Galmashira	20	0	1.9 ± 1.0	0.9 ± 0.7	0.2 ± 0.2	0	0.4 ± 1.1
Lowland							
Anood	20	2.6 ± 0.5	6.1 ± 2.1	2.3 ± 0.5	1.0 ± 0.3	2.0 ± 0.9	0.4 ± 0.5
Awsharif	20	2.3 ± 0.5	5.5 ± 1.5	2.5 ± 0.6	0.7 ± 0.6	1.7 ± 0.6	0.3 ± 0.1
Berkale	20	2.6 ± 0.7	6.0 ± 3.8	2.2 ± 1.4	1.1 ± 1.0	1.1 ± 1.0	0.4 ± 0.8
Burka	20	2.6 ± 0.7	6.0 ± 3.7	0.9 ± 0.8	0.2 ± 0.2	1.0 ± 0.0	0.5 ± 0.1
Erer	20	0	1.5 ± 1.1	1.0 ± 0.8	0.2 ± 0.2	0.0 ± 0.1	0.0 ± 0.1
Ifadin	20	2.1 ± 0.3	3.0 ± 1.7	1.8 ± 1.1	0.6 ± 0.6	0.5 ± 0.6	0.1 ± 1.3
Kile	20	1.0 ± 0.0	1.7 ± 1.0	1.0 ± 0.9	0.2 ± 0.3	1.0 ± 0.6	0.6 ± 1.3

Growing sorghum as a food grain is widely practised by individuals of all the farmers' associations surveyed. Chat production was not only limited to the highland areas, but it was spreading to the lowland areas as well, with an average of 0.6, 0.4 and 0.4 ha/household for Kile, Berkale and Anood FAS respectively (Table 3.5). Groundnut was predominantly grown in Anood, Awsharif and Berkele FAS on land sizes of 2.0, 1.7 and 1.1 ha respectively.

The average pasture land available to the members of the farmer's association is given in Table 3.5. There was about 1.42 ha grazing land/household. No plants were grown as fodder in the area surveyed. The main system for keeping cattle is that of zero-grazing and/or tethering on the side of the farm using a cut-and-carry system of feeding. Hence, the cut-and-carry system was predominantly practised at many of the locations, except for Anood, Awsharif, Barkale, Ifadin, Burka and Kile FAS where grazing is the predominant system for keeping cattle.

The Anood, Berkale and Burka FAS had the largest area of pasture land (2.6 ha) per household, while the Galmashira and Awberkale FAS had none. All pastures were natural grasslands and no cultivated pastures were available at any site. These natural pastures are continuously degrading as a result of mismanagement (i.e. overgrazing) as reported by the farmers. Similar reports have been made by the RSO (1998).

3.4.2 Land tenure and traditional practices

Average yield of crop residues and Total Tropical Livestock Unit (TLU) per household in the rural areas of Harar milkshed are presented in Table 3.6.

The size of the land holding and therefore the yield of crop residues, as well as the TLU per household vary greatly, and are generally seen as one of the main determinants of the level of intensification (Tables 3.5 and 3.6).

Table 3.6 Crop residue yields and tropical livestock units (TLU) per household (mean ±sd) in the rural area of the Harar milkshed

Location	Number of households	Crop residues kg/ha	TLU*
Rural	200	6700	8.026
Highland			
Awberkale	20	1065 ± 164	3.3 ± 1.1
Awsharif	20	429 ± 125	11.5 ± 5.0
Deretayara	20	1002 ± 409	4.2 ± 1.8
Erer	20	780 ± 913	7.8 ± 1.8
Lowland			
Anood	20	405 ± 109	15.3 ± 7.7
Berkale	20	411 ± 105	10.2 ± 6.1
Burka	20	449 ± 152	6.5 ± 1.2
Galmashira	20	957 ± 364	4.3 ± 1.8
Ifadin	20	822 ± 527	10.1 ± 5.2
Kile	20	420 ± 18	7.1 ± 1.8

TLU = One Tropical livestock unit is equivalent to a mature cattle of 250 kg live weight.

* Coefficients for estimating TLU=adult cattle=0.7; adult sheep & goats 0.1; donkey 0.5; camel=1.0; weaner cattle= 0.5; weaner sheep and goats 0.07; suckling animals cattle 0.2; sheep & goats 0.03 (ILCA, 1993).

Mean TLU and total production of crop residues per household in the Harar milkshed was estimated at 6700 kg and 8 TLU respectively, with great variation per household. The highest TLU per household was in the Anood FAS and the lowest in the Awberkale FAS. The highest crop residue yields were in Awberkale and the lowest in the Anood FAS. Land size was not in proportion to the number of livestock (expressed as TLU) in the different FAS. For those farmers associations' where land sizes are small (below average) in relation to the TLU, land is thus a primary constraint to production and farmers are forced to intensify.

In Ethiopia farmers do not own land, because by law land cannot be sold or exchanged except by inheritance (GOE, 1986). Land tenure (traditional tenure) is therefore based on the right to use the land; a right can be inherited.

It was also attempted to investigate the changes that took place over time on the type of crops grown in the area. During group discussions with key informants and farmers, the farmers expressed concern about the changes observed in the crops grown presently that were not grown in the past. It was noted from the discussion with the farmers and observations of the area that in the highlands coffee is being replaced by chat, grazing land is shrinking and there is serious soil degradation.

Almost all communal grazing lands are now under crop production, which has caused a decrease in the livestock numbers as well as a reduction in livestock production. A similar report of the Harari regional state (PEDB, 2000) supports these views and asserted that there is little or no grazing areas left for livestock in the region. This was the result of population growth and subsequently an increased demand for food for the human population.

It was noted that in the lowland, the pastoral mode of cattle production is progressively changing to a settled form of livestock production. There was a very small number (9%) (Table 3.1) of pure pastoralist in the area and further intensification is in progress.

Similar observations were reported from other pastoralists' areas in the country. Tezera & Belay (2000) found that 10 years ago in the Jijiga pastoral areas, about 42% of the households were engaged in crop farming to support the household needs for food. According to ILCA (1984) there was very little crop production in Eastern Hararghe until the 1940's, but in the 1970's about 10% of the total area were used for crop production.

It is estimated that 50% of the total population in the area are currently engaged in crop production (Holt & Richard, 1995). Farmers noted that this intensification has exposed their livestock to a number of diseases (e.g. parasitism, pasteurellosis, brucellosis and some new diseases) which substantially reduced their livestock herds.

Plantation of *Chat* was also noted as a new phenomenon in the area.

3.4.3 Farm infrastructure and means of transportation

The majority of the rural households (66%) had only animals as a means of transport available, such as donkeys and camels in certain cases (Table 3.7). The donkeys were mainly used for transporting the household supplies, farm inputs and agricultural products, except milk. Milk was usually delivered to the market centres by women. About 29% of the households had no means of transport whatsoever, while the remaining 5% of the households had a combination of animal power and human labour for transportation. There was only a small number (8%) of urban households with motorised transport, while about 38% of the households had only human labour and wheelbarrows as means of transport, slightly better than that of rural areas.

Table 3.7 Means of transportation available to the rural and urban households in the Harar milkshed

Location	Number of households	Vehicle	Wheelbarrow	Donkey	Camel
Rural	200	0	3	85	46
Urban	50	4	15	4	0

The remaining 55% had no transport whatsoever and depend on either manpower, renting a donkey or truck for a group when the need arose, for example, when transporting a large load of livestock feed from the brewery factory to their farms. Donkeys are also commonly used for transportation from nearby sites to their respective places, particularly where it is not accessible for trucks. This means motorised transport was actually in many instances organised by a group and not individually.

3.4.4 Labour resources

The allocation of household and hired labour for dairy related activities in the rural and urban dairies are summarised in Tables 3.8 and 3.9 respectively.

In general, the rural households did not hire labour and relied solely on family labour. In the rural area adult males, adult females, both adults, general household and children are responsible for 20, 58, 2, 1 and 19% of dairy activities (Table 3.8). As expected, the high percentage of females involved can be attributed to women being mostly responsible for milking, cleaning of the shed and milk sales.

Table 3.8 Allocation of household labour (%) to rural dairy farm activities in the Harar milkshed

Activities	Adult males	Adult females	Both adults	General household	Children
Grazing/cut-and-carry	50	14	12	4	20
Milking	0	90	0	0	10
Milk processing	0	100	0	0	0
Sale of milk	0	90	0	0	10
Spray	80	0	0	0	20
Cleaning barn	0	100	0	0	0
Watering herding	10	10	5	5	70
Average	20	58	2	1	19

The responsibility of the urban households in terms of labour for dairy activities are 15, 16, 4, 4, 9 and 52% for adult males, adult females, both adults, general household, children and permanent labour (Table 3.9).

The low percentage for adult females engaged in urban dairies can be explained by the fact that males generally own and make the decisions on the farm as it requires a relatively high investment from the household. Thus, purchasing the supplies, obtaining veterinary services and AI technicians are probably major attributes of their activities in the dairy management.

Table 3.9 Allocation of household and hired labour (%) to urban dairy farm activities in the Harar milkshed

Activities	Adult male	Adult female	Both adults	General household	Children	Permanent labour
Grazing/cut-and-carry	10	0	0	0	0	90
Milking	10	20	5	5	5	55
Milk processing	0	20	0	0	10	70
Sale of milk	10	20	5	5	10	50
Spray	0	0	0	0	20	80
Cleaning barn		30	0	0	20	50
Watering herding	5	5	10	10	5	65
Obtaining AI/ Veterinary service	40	30	10	10	5	5
Purchase feed	65	20	5	5	5	0
Average	16	16	4	4	9	52

The household labour may normally be involved in some sporadic activities that occasionally include fetching veterinarians and AI technicians. All the external labour in the urban dairies was permanent labour and no casual labour was employed. The proportion of permanent labour to household labour was 1.8 ± 1.1 and 1.4 ± 1.1 respectively. The majority (90%) of the external labour came from other regions, particularly from Gojam in the Amhara region of Ethiopia, about 1000 km North West of Harar. Only 10% of the labour was from the Harari region.

Harar is one of the important trade centres in eastern Ethiopia, hence, a shortage of labour exists which makes it easier for the people of the area to obtain less menial but higher paying jobs. This tends to make it difficult for the dairy farmers to obtain labour for a relatively reasonable cost. Added to the general shortage of labour, the general lack of knowledge in dairy cattle management is also a major problem. Food and shelter is provided for permanent labour, depending on the monthly salary. If the labourer is paid 100-150 Birr/month he/she is entitled to get food and shelter in most cases. If he/she is paid a little more, say 300 Birr/month, then no food and shelter are provided. This is only half of the minimum wages in the same area (20 Birr/day). These salaries are less attractive to the labourers on the dairy farm. This finding suggests that the role of dairies is important in generating job opportunities both inside and outside the regions. It also suggests that there is a serious constraint of labour in the region, in Harar in particular.

3.5 LIVESTOCK RESOURCES

3.5.1 Ruminant livestock inventory

The type of livestock owned by households is presented in Table 3.10. Almost all farmers (95%) keep livestock. The most common livestock in the Harar milkshed is cattle (95%), followed by donkeys (43%), sheep (38%) and goats (11%). These values particularly for cattle, are higher compared to the value of 55% provided by ECSA (1999) and the 44% provided by the DPPD (1998). They reported that the most abundant ruminants are cattle followed by goats (30 and 21%), camels (1.2 and 20%) and sheep (6 and 8%) for the Harari region and Babile district of the Harar milkshed. The higher percentage for cattle may be as the result of the sample's inclination to dairy cattle owners in the study area.

Table 3.10 The number of households owning different species of livestock in the Harar milkshed

Location	Number of households	Cattle	Goats	Sheep	Donkey	Camel	Chicken
Rural	200	191	22	68	85	46	98
Urban	50	50	0	3	4	0	13

The results of the ruminant inventory in the surveyed areas of the Harar milkshed are presented in Table 3.11. The ruminants include local cattle (Ogaden cattle), black head Somali sheep and local goats. The predominant cattle type in the Harar milkshed is classified as zebu/short zebu and is described as having a considerable adaptability to a harsh climate, poor nutrition and endemic diseases (Alberro & Haile Mariam, 1982).

The highest number of cattle per household observed was in Anood FAS followed by Awbsharif, Erer and Burka FAS. The lowest number of cattle per household was seen in Berkale, Galmashira and Deretayara FAS. In the highlands, mixed livestock farming, the raising of cattle in a combination with small ruminants is common. In the lowlands, keeping different animal species including camels, Anood, Awsharif, Berkale and Ifadin FAS with cattle is also common.

Table 3.11 The number of ruminants per household (means ±sd) in the Harar milkshed

Location	Number of households	Cattle	Sheep	Goats
Urban	50	18.0 ± 16.3	0.3 ± 1.3	0
Rural	200	6.6 ± 4.4	2.3 ± 3.6	7.1 ± 4.1
Highland				
Awberkale	20	4.4 ± 2.0	2.1 ± 1.7	3.5 ± 2.4
Deretayara	20	4.2 ± 2.4	1.6 ± 1.6	1.9 ± 1.3
Galmashira	20	4.2 ± 2.1	2.0 ± 1.6	3.3 ± 2.1
Lowland				
Berkale	20	4.2 ± 2.4	3.2 ± 3.8	4.1 ± 3.2
Burka	20	7.7 ± 3.0	1.1 ± 1.7	4.2 ± 3.1
Erer	20	7.7 ± 2.4	1.2 ± 1.2	4.6 ± 3.2
Awsharif	20	7.6 ± 6.0	4.9 ± 5.8	18.7 ± 10.3
Ifadin	20	4.9 ± 2.4	4.0 ± 3.3	12.9 ± 10.7
Kile	20	6.8 ± 3.3	1.4 ± 1.1	5.4 ± 4.3
Anood	20	14.7 ± 11.7	1.7 ± 2.0	12.6 ± 9.5

Farmers, including the agropastoralists in the lowland, use these mixed livestock rearing strategies mainly for economic and biological reasons as well as for risk aversion schemes. Similar findings were reported by Dahl & Hjort (1976) and Ayan (1984) in Somalia. These authors noted that different livestock species can utilize different plant materials on a given grazing area more efficiently than a single species. Farmers with different species of livestock are less susceptible to the devastating effects of natural calamities than those with a single livestock species, particularly in drought affected areas.

Cattle are not only kept for their direct function in the farming systems, i.e. providing milk, draught power, manure and cash, but also accumulate assets obtained from their growth (weight gain and fattening) and progeny obtained from the calves (Ifar, 1996). Cattle are preferred to achieve these goals because apart from being a source of milk, draught power and manure, they are also sold at much higher prices. When farmers were asked when and why they sell ruminants, none mentioned maximising profit or income. The answers always concentrated on the need of having money for specific reasons (e.g. to pay tax, to build a house, to purchase clothes for the family or to have a wedding).

Cattle are sold in the livestock markets located in Babile and Harar. The choice of the market depends on the proximity to these towns. The selling of cattle is usually performed through a middle man in the livestock market. The price is determined by the physical appearance of the animal, body condition and personal judgement and not on a live weight basis. Rural households who do not keep cattle generally said that they did not have labour in the household to collect feed and to herd the animals, or lacked the capital to buy animals or did not have sufficient feeds. In some places (e.g. Ifadin FAS) however, cattle can be obtained through systems of animal-sharing arrangements. This animal-sharing arrangement involves a sort of agreement between the cattle owner and the needy farmer for cattle. The agreement normally states that the needy farmer will enter into this agreement to feed and manage the cattle and enjoy the milk obtained from the cow and share the calves born with owner in turn. The first calf will go to the owner the second calf reverts to the needy farmer.

However, farmers mentioned difficulties involved in obtaining shared animals because it requires a prerequisite to have such an opportunity. It means a trustworthy person is required as a guarantor and/or the cattle owner has to be a relative of the needy person.

Sheep are mostly prevalent in the highlands, but currently, it seems that even under highland conditions goats are increasing in number, e.g. the Deretayara and Galmashira FAS (ECSA, 1999; DPPD, 1998). This may be attributed to two reasons. Firstly goats' milk can to a certain extent replace cow's milk and contribute to satisfy the household needs, e.g. *Hoja* a locally made hot drink mix with cattle/goat milk. Secondly, goats' meat is in greater demand by consumers mainly for its low fat content, hence, it fetches better returns than sheep.

In the urban dairies, cattle are kept mainly for milk production. A few farms (6%) keep a small flock of sheep. Goats were not recorded on any farms in the urban areas and this may be because of its destructive nature as mentioned by some farmers during the interviews. Due to their browsing habits, mismanaged goats can destroy small trees.

3.5.2 Non-ruminant livestock inventory

3.5.2.1 Fowls

Most fowls are of indigenous local breeds with a few crossbred birds prevailing in and around the towns. Fowls are kept in small flocks ranging from 2 to 10 birds, kept by nearly all the households. They are subsisting as scavengers, requiring little or no input in terms of feed and labour, thus giving a low output in the form of eggs (36 eggs/year) and meat (0.5-1 kg) (ARDU, unpublished). They also serve as a source of cash income and play a role in the household economy when a small amount of cash income is needed, e.g. to buy salt and kerosene for the household. The cash obtained from selling a bird is reported to be Bir 5-20/bird or equivalent to US$ 0.25–2/bird. Depending on the season the price inflates very rapidly when the demand increases during the religious festivals.

3.5.2.2 Equines

The main equines kept in the Harar milkshed are donkeys. No horses and mules were reported in the survey. Donkeys are used as pack animals and not for ploughing.

Donkeys and cows are normally not used for ploughing because farmers think that these do not have sufficient power and secondly, because of cultural norms. However, in Ifadin FAS, it was found that under certain circumstances donkeys can be used, especially at times when there is a shortage of draught power for crop production activities. Some farmers use both cows and donkeys for ploughing. The implications of this interesting finding to the farming community should be borne in mind by the future research and extension efforts. The mean number of non-ruminant livestock (Table 3.12) was 1.58 camel, 0.48 donkey and 2.7 fouls respectively for the rural households in the Harar milkshed. The highest number of donkeys was reported in Erer FAS and the lowest number of donkeys was reported in the Awsharif FAS (Table 3.12).

Table 3.12 The number of non-ruminant livestock per household (mean ±sd) in the Harar milkshed

Location	Number of households	Camels	Donkeys	Fowls
Urban	50	0	0.0 ± 1.1	1.1 ± 3.5
Rural	200	1.6 ± 2.4	0.5 ± 0.8	2.7 ± 3.1
Highland				
Awberkale	20	0	0.6 ± 0.5	3.2 ± 3.4
Deretayara	20	0	0.5 ± 0.6	5.7 ± 3.7
Galmashira	20	0	0.6 ± 1.1	4.3 ± 3.5
Lowland				
Anood	20	4.7 ± 6.2	0.3 ± 0.6	0.9 ± 3.6
Awsharif	20	4.5 ± 4.1	0.3 ± 0.4	4.9 ± 6.1
Barkale	20	0.4 ± 1.2	0.4 ± 0.7	1.0 ± 3.4
Burka	20	0	0.6 ± 0.7	1.5 ± 1.8
Erer	20	0.4 ± 0.9	0.6 ± 0.6	1.1 ± 1.3
Ifadin	20	5.9 ± 10.8	0.5 ± 0.5	3.0 ± 3.2
Kile	20	0	0.8 ± 1.9	1.9 ± 1.9

This higher number of donkeys reported in Erer FAS and a lower number in Awsharif FAS probably tends to be correlated with the distance to the market places and the farming system used (correlation coefficient of 0.18 and highly significant $P<0.01$). The $R^2=0.03$ which means only about 3% had donkeys in the Erer FAS. However, the correlation between the donkey population with crop land was not significant ($P<0.05$). This means places like Erer FAS that are too far from market places and that has sorghum-dairy systems, would tend to make more use of donkeys, compared to Awsharif FAS being a livestock-crop area where there is not much crop produced and inputs like fertilizers and seeds to transport.

3.5.3 Camels

The Ifadin, Anood, and Awsharif FAS had the highest number of camel, while Erer and Berkale FAS had the lowest number of camels among the camel rearing areas. The remaining areas had no camels mainly because of agro-climatic reasons (Table 3.8). Camels in this area are regarded as one of the most important animals as indicated by the farmers. Available literature (Teka, 1991; Zeleke, 1998; Tezera & Belay, 2000) also supports this idea in various instances such as for religious ceremonies (funerals and scarification, paying palms) cultural for dowry payment and for wedding ceremonies camels are highly valued by the owners particularly the Somalis.

Camels are one of the most important livestock species in dry and semi-arid areas of Ethiopia, providing millions of pastoralists' with a means of subsistence, particularly in the eastern region of the country. The eastern part of the country is usually referred to as the home of the large camel populations, where more than two thirds (900 000) of the nation's camels prevail (ECSA, 1999). Camels in the study area are used for their milk, meat, transport and sometimes also as draught animals (Teka, 1991; Tezera, 2000). Camel milk and meat are highly consumed and sometimes even preferred to cattle milk in the area (Tezera & Bruckner, 2000) and also as the meat source (Kurtu, 2002). Apart from the food value, it is believed by the consumers that camel milk and meat have medicinal values (Tezera & Bruckner, 2000; Kurtu, 2002). Milk off-take from camels ranges from 3-8 kg/ female/day, depending on the season of the year (Zeleke, 1998; Tezera & Bruckner, 2000). Camel milk supply is relatively consistent between the wet and the dry seasons (Elmi, 1991), hence it plays a buffering role in milk supply to Harar town, particularly during the dry season when cattle milk supply decreases substantially. Similarly, the meat produced by camels plays an important role in Harar and is a substitute for cattle in Jijiga town, when beef becomes scarce during the dry season (Kurtu, 2002). In addition, camels are considered to have superior social, cultural and religious values than other livestock species in Muslim communities in general, and for the Somalis in particular (Tezera & Bruckner, 2000).

3.5.4 Priority and preference for cattle

In almost all areas surveyed, cattle are the preferred livestock species by the farmers. Cattle are preferred because they give a higher income than goats and sheep, apart from other uses. In Awsharif, Barkarley, Anood and Ifadin FAS, goats were kept only by 42%, 40%, 46% and 30% of the farmers respectively. Goats are kept in these areas because there are relatively more rangelands with grass, bushes and trees providing feed for livestock. In the Gelmashira, Burka and Kile FAS where sheep populations seem to be less popular, farmers believe that goats can provide milk and be sold for a better price at the market. In addition, goats grow faster and reach market weight earlier than sheep. However, there are also farmers in the highlands (Deretayara FAS) who still opt to keep sheep with their poor body weight gain, because they think that goats are destructive, especially in crop-livestock farming areas.

3.5.5 Reasons for keeping cattle

The farmer's ranking of the reasons for keeping cattle are presented in Table 3.13. Most farmers (33%) stated the production of milk, meat (21.5%) and draught power (18.5%) as the primary objectives of rearing cattle, followed by manure, income generating and savings. Farmers referred to their cattle as a form of saving that provides security. As a form of capital saving objective cattle have a higher priority in the Anood, Awsharif and Erer FAS than in the Galmashira, Deretayara, and Awberkale FAS. However, in the highland area, farmers did not rank the option of using cattle for draught as primary and not even a secondary priority, as is usually the case in the highlands (Kurtu & Mulat, 1997). This was probably influenced by several factors including the land quality (soil is often too shallow to be ploughed in places like Ifadin FAS) and the size of the plot which is too small and can be prepared within a few days using a traditional hoe (*Akafa)*. This is the most dominant feature in the eastern region in general and in the study area in particular. The type of crop, such as *Chat* mixed with sorghum which is not practiced for using oxen for ploughing, is another factor that contributes to opting for ploughing by manpower. The use of a hoe (*Akafa)* usually requires a group of people to do the ploughing and related operations of land preparation in time. For this reason, villages have a tradition of reciprocal helping or assistance rendering systems called *Guza*. The members of the community pool their labour to help each other without payment to prepare land, build houses and perform other related activities. Under this tradition, those who receive help with land preparation will provide meals, *chat* and hot drinks (*Hoja*) to motivate the helpers.

Table 3.13 Priority ranking (%) for the reasons given as the main purpose for farming with cattle in the Harar milkshed

Location	Milk	Draught	Fattening	Manure	Cash income	Security
Highland						
Awberkale	30	40	10	0	20	0
Deretayara	30	25	20	10	15	0
Galmashira	25	10	35	20	10	0
Lowland						
Anood	50	5	5	0	10	30
Awsharif	40	20	10	0	10	20
Berkale	35	20	30	0	10	0
Burka	20	20	30	10	20	0
Erer	20	15	20	5	10	30
Ifadin	50	5	25	0	20	0
Kile	30	25	30	5	10	0
Average	33%	18.5%	21.5%	5%	13.5%	8%

0 = There was no priority ranking.

The farmers in the Anood, Awsharif and Awberkale FAS accorded a very low priority to beef (fattening) and manure production as resource for keeping in their cattle.

Farmers in these areas consider beef production not possible because of lack of feed and competition with milking cows for feed if the animals are underfed and have to be fed. This could be risky, because animal could either die or become so emaciated that it cannot fetch a good price. Nevertheless, they are concerned about the weight and condition of their cattle because it determines the price.

3.5.6 Cattle numbers and breed types in the Harar milkshed

The type pf cattle kept by farmers depends on the type of use or purpose for farming and the production system used. Improved dairy cattle (crossbred or exotic) are predominantly present in urban dairy systems while indigenous cattle are found in rural areas. As shown in Table 3.11 the mean number of cattle per household were 14.65, 4.2 and 4.2 for the Anood, Berkale and Gelmashira FAS respectively. As expected, the largest herds were found in the extensive grazing areas in the Anood FAS followed by the Berkale FAS with more than 14 head of cattle per household. The Awsharif FAS also had a relatively larger herd (7.6) and a larger land size per household. The mean herd size/household in the Harari region was smaller but showed a trend for intensification in that the dairy farmers are keeping on average 4.2 cows on small areas of land. Similar results were obtained in Kenya (SDP, 2001). In urban areas, the average cattle herd size was 18/household, all being stall-fed. The average number of cows/household was 8.5 and almost all were Friesian or Friesian crossbreds with *Bos indicus* (zebu). This corresponds with the farmers' views expressed during the discussion that Friesian cattle are preferred owing to their higher milk production and traction power.

3.5.7 Cattle herd composition

Cattle herd composition is presented in Table 3.14. About 41% of the herds are composed of adult cows, which together with heifers accounted for nearly two thirds of the total herds. This is a strong indication that the main reason for keeping cattle is to produce milk. Bulls comprise about 21% of the herd. A similar number of male and female calves indicate that the male animals would normally stay in the farm until maturity. In the Harari highland areas, where crop farming is the main activity and land is a major constraint, cows constitute about 78% of the total herd and bulls about 22% and is higher than for the lowlands.

Table 3.14 Cattle herd composition per household (mean ±sd) in the Harar milkshed

Location	Number of households	Cows	Heifers	Oxen
Urban	50	16.3 ± 1.9	8.4 ± 3.7	0.6 ± 0.5
Rural	200	3.1 ± 2.4	1.9 ± 1.6	1.7 ± 1.2
Highland				
Awberkale	20	0.9 ± 0.5	1.0 ± 0.8	1.0 ± 1.2
Deretayara	20	2.5 ± 1.6	0.9 ± 0.6	1.0 ± 0.8
Galmashira	20	2.5 ± 1.6	0.9 ± 0.6	1.0 ± 0.8
Lowland				
Anood	20	5.1 ± 4.2	3.5 ± 3.7	3.7 ± 3.5
Awsharif	20	2.8 ± 2.8	1.5 ± 1.2	1.0 ± 1.2
Berkale	20	4.4 ± 3.6	3.5 ± 4.6	3.5 ± 5.6
Burka	20	3.3 ± 1.3	2.1 ± 1.6	2.1 ± 1.4
Erer	20	4.1 ± 2.2	2.4 ± 1.1	1.9 ± 1.0
Ifadin	20	1.8 ± 1.0	1.2 ± 0.8	0.6 ± 0.7
Kile	20	3.9 ± 1.9	1.8 ± 1.3	1.9 ± 0.9

The higher number of females kept may be primarily to get enough milk and to have replacement stock that could also continuously provide male offspring for ploughing and fattening. However, in the lowlands, where the land is not limiting and crop production is not the main activity, the composition of the herd particularly the prevalence of higher number of males is unexpected when viewed in relation to the farming system and the purpose of cattle raising. The lowest number of oxen was noted in Awsharif (11%) and Ifadin FAS (13%), while Anood and Berkale FAS showed 25 and 24% respectively, higher than expected for the highlands. A higher percentage of cows were observed in general across the locations compared to other classes of cattle. This may be owing to poor breeding efficiency of the local animals combined with the desire of farmers to get oxen in a sustainable manner on the farm, instead of just milk production (Tegegne, 1997). A lack of culling of poor producers could also be another explanation for the higher number of adult cows in the herds including in the urban dairy areas. This could mainly be because of a lack of knowledge and awareness of modern husbandry practices.

3.5.8 Productive and reproductive performances

In the rural areas farmers use only indigenous cattle breeds while in the urban areas they use crossbred and upgraded cattle (Friesian type). Hence it was found to be more useful to analyse animal performance data by dairy systems (Tables 3.15 and 3.16).

Table 3.15 Ages at weaning, first service and first calving (mean ±sd) in the Harar milkshed

Location	Number of households	Weaning age (months)	Age at first service (months)	Age at first calving (months)
Urban dairy	50	5.0 ± 0.7	22.5 ± 4.9	31.1 ± 3.9
Rural	200	7.7 ± 0.7	40.6 ± 4.5	52.0 ± 4.6
Highland				
Awberkaley	20	8.2 ± 2.8	41.2 ± 5.7	49.6 ± 5.8
Deretayara	20	6.5 ± 1.7	45.7 ± 3.3	56.8 ± 2.4
Galmashira	20	6.5 ± 1.7	45.6 ± 3.3	57.1 ± 2.7
Mean ±sd		7.1 ± 2.1	44.2 ± 4.1	54.5 ± 3.6
Lowland				
Anood	20	7.5 ± 2.6	40.4 ± 8.8	53.7 ± 9.3
Awsharif	20	8.3 ± 1.6	37.4 ± 9.5	49.0 ± 10.2
Barkaley	20	8.2 ± 2.6	35.8 ± 8.0	47.6 ± 8.9
Burka	20	7.6 ± 2.3	36.3 ± 10.3	47.4 ± 11.1
Erer	20	8.7 ± 2.8	48.0 ± 5.5	59.3 ± 4.7
Ifadin	20	8.2 ± 2.7	35.4 ± 8.1	46.8 ± 9.1
Kile	20	7.6 ± 2.3	40.3 ± 5.5	52.4 ± 6.0
Mean ±sd		8.0 ± 2.4	39.0 ± 8.0	50.9 ± 7.2

For the urban dairies with their crossbred and upgraded cattle, mean age at first service and mean age at first calving were 22.5 and 31.06 months respectively (Table 3.15). Lactation length and calving intervals were 322 and 498 days respectively. The prolonged calving intervals may be owing to a number of reasons that included a lack of timely mating, limited access to reproductive services (AI), difficulties associated with heat detection and diseases. Similar findings were reported by

Kuwiwa *et al.* (1983) and Kurtu *et al.* (1999). The mean age at first service and calving age of local cattle were 40.6 months and 52 months respectively, which are about 18.1 and 20 months longer than for the crossbred cattle. Mean lactation length and calving interval for the local cattle were 212 and 765 days respectively.

The mean calving interval (Table 3.16) for local cattle was 267 days longer than crossbred cattle and the lactation length of local cattle was shorter by 110 days than the crossbred cattle. These results are supported by Kiwuwa *et al.* (1983) and Kurtu *et al.* (1999). As shown in Table 3.16 the mean lactation yield for the local cattle is 229 liter while the lactation yield for the crossbred cattle is almost ten times as much (2170 liter). In the highlands of the Arsi region of Ethiopia, it was reported that crossbred cattle produced more than seven times as much milk as local Arsi cattle (Brannang *et al.*, 1980; Kuwiwa *et al.,* 1983; Kurtu *et al.,* 1999). No direct comparisons regarding milk production was made in this study. However, the low level of productivity of the local zebu cattle as cited is probably attributed to the fact that these local cattle have been selected primarily for survival rather than production traits; they have established adaptive traits to the harsh environment in which they live with a low milk yield. Low productivity is an important adaptive strategy to survive in harsh environments. These zebu breeds are adapted to low input-low output production systems. However, livestock production systems in the Harari rural areas are mainly small-scale based farming. These farmers normally keep local cattle for multipurpose functions and as such no selection is made for milk production. Given their low genetic potential for production traits, the multi-purpose use and predominantly low input production systems, these breeds are still important for rural economies where the feeding and management are poor. It might be difficult to introduce improved breeds before the feeding and management conditions are improved. In addition it must be noted that direct comparison of the productivity of these local cattle breeds with the specialized European dairy breeds will not be only difficult but unfair and unjustifiable. Similar arguments have been made by Tegegne & Alemu (1998).

Milk production, consumption and marketing figures were reported in bottle units by farmers and have been converted into liter. Rural households produced 3.25 liter per day of which they consumed 1.5 liter and sold 1.75 liter of milk per day (Table 3.17). A similar report was made by the ECSA (1994), namely that more than 65% of milk usually produced is used for home consumption and/or may be processed into butter. This is one of the reasons of low milk delivery to the market for urban consumption apart from the lower productivity of the local cattle. The lower productivity of these local cattle is associated with their genetic composition and the harsh environment (nutrition) in which they are managed (Table 3.16).

Table 3.16 Total milk yield (liter), lactation length (days) and calving interval (days) (mean ±sd) in the Harar milkshed

Location	Number of households	Milk yield	Lactation length	Calving interval
Urban dairy	50	2170.0 ± 897.0	322.1 ± 45.9	498.4 ± 78.0
Rural	200	229.0 ± 56.4	212.9 ± 28.2	765.6 ± 12.1
Highland				
Awberkaley	20	197.2 ± 79.8	232.1 ± 81.8	644.2 ± 73.9
Deretayara	20	224.5 ± 44.6	191.8 ± 45.5	615.2 ± 75.8
Galmashirs	20	265.7 ± 50.8	192.5 ± 46.7	630.8 ± 76.6
Mean ±sd		229.1 ± 58.4	205.5 ± 58.0	630.1 ± 75.4
Lowland				
Anood	20	299.4 ± 74.1	274.7 ± 70.2	890.7 ± 78.8
Awsharif	20	167.5 ± 74.0	198.2 ± 74.0	864.8 ± 30.2
Barkaley	20	172.8 ± 55.0	205.8 ± 62.0	823.2 ± 56.5
Burka	20	215.2 ± 92.0	195.6 ± 80.0	846.1 ± 41.3
Erer	20	153.1 ± 78.8	243.0 ± 79.6	615.4 ± 76.1
Ifadin	20	317.5 ± 56.8	206.2 ± 64.8	864.2 ± 30.7
Kile	20	175.8 ± 98.5	189.0 ± 93.7	864.7 ± 30.2
Mean ±sd		214.5 ± 75.6	216.1 ± 85.6	852.7 ± 49.1

Average milk production per day is very low by all standards and the total milk production is further affected by relatively short lactation length (Table 3.16). Similar observations were made by Brannang *et al.* (1980) and Kiwuwa *et al.* (1983) that the average milk offtake from Zebu cattle seldom exceeds 300 kg in one lactation and the lactation period is normally less than 200 days. In addition, an extended post-partum anoestrus period resulting in lower efficiency was noted (Mukasa-Mugrewa, 1989). This is probably due to the fact that these animals have been selected for survival rather than for production traits; they have established adaptive traits to the harsh environment in which they live with the ability to produce some milk. The already long calving intervals for the rural dairy farms were considerably longer in the Lowland compared to the Highland.

Table 3.17 Quantities of milk produced, consumed and sold per day (mean ±sd) per household as well as the price of milk in the Harar milkshed

Location	Produced (liter)	Consumed (liter)	Sold (liter)	Price per liter (Eth Birr)
Urban		-	87.6 ± 11.1	2.5
Overall	3.0 ± 0.8	1.6 ± 0.6	1.7 ± 0.8	1.7
Highland				
Awberkaley	3.8 ± 0.9	2.5 ± 1.0	1.3 ± 1.1	2.5
Deretayara	2.4 ± 0.5	1.4 ± 0.5	1.0 ± 0.8	2.5
Galmashira	3.6 ± 0.3	2.0 ± 0.5	1.6 ± 1.1	2.5
Lowland				
Anood	3.3 ± 0.6	1.5 ± 1.3	1.8 ± 0.3	1.5
Awsharif	2.8 ± 0.3	0.9 ± 1.2	1.9 ± 0.0	1.5
Barkaley	2.8 ± 0.5	1.2 ± 1.8	1.6 ± 0.0	1.5
Burka	3.6 ± 0.7	2.3 ± 0.8	1.3 ± 0.6	2.0
Erer	2.5 ± 0.6	1.4 ± 0.6	1.0 ± 0.9	2.5
Ifadin	2.8 ± 0.5	1.5 ± 0.0	1.3 ± 0.9	2.0
Kile	2.8 ± 0.4	1.5 ± 0.1	1.3 ± 0.8	2.5

The largest quality of milk consumed was in the Awberkaley FAS, which probably reflects a lack of market access, and the Deretayara FAS which might reflect a better income from *chat* crops. The amount of milk sold varied across the locations, with the highest being in the Anood and Barkaley FAS. These areas produce more milk despite their distance from the markets owing to the fact that they have a larger herd size, larger grazing areas and camel herds as well, which provide the bulk of milk for home consumption. In addition, it also seems that they are more dependent on milk sales than farmers in the highlands. The highest price in the rural areas (Eth Birr 2.5 per liter) was paid in the Galmashira, Deretayara. Erer, Kile and Awberkaley FAS. Prices paid by all market agents are based on volume and not composition of milk. Although the price of milk appears to be reasonably high, shortages of land, feed resources and human labour seems to make the dairy sector less developed in the Harar milkshed.

3.5.9 Water supply for livestock

Water supply for livestock is not adequate and farmers have no option in most cases to walk their livestock (trekking) a long distance daily in search of water.

The information in Table 3.18 shows that only in Harar and Galmashira FAS, with apparently good infrastructures, about 80% and 20% respectively reported using piped public water supplies for their dairy cattle. The majority of the rural farmers (51%) use rivers and ponds. These rivers and ponds are in most cases dry during the dry season, forcing the farmers to trek their animals a longer distance to get to water sources. Farmers in Anood, Barkaley and Kile FAS especially have to travel longer distances to collect water from either a well or a river. Only about 11% of those farmers located closer to Babile and Harar reported getting water from piped public water. Even those farmers who use public piped water, especially in the Harar area including Harar city, very often suffer from severe water shortages. Harar gets water from Lake Alemaya, located about 20 km to the northeast. Lake Alemaya is progressively drying owing to a number of complex environmental factors. In addition, numerous rivers around Harar are already getting drier due to environmental factors that include deforestation, erosion and a lack of appropriate water resource management, to mention only a few. These factors have tended to aggravate the water shortages and as a result, Harar is currently referred to as one of the cities in Ethiopia that suffers from acute water shortages, particularly during the dry season. The regional government at the moment, however, tries to get some water using groundwater sources from Dire Dawa through a pipe line of 55 km to ensure a permanent water supply to Harar and its surroundings (PEDP, 2000).

3.5.10 Livestock breeding and management

In the rural setting, all farmers use natural mating and the breeding bulls are raised by the farmers or borrowed from neighbours. Thus, natural selection seems to be the most dominant feature in the breeding practices in the rural areas. Owners of large herds do practise selection based on the milk yield and body size, hence, they look for a bull with a good progeny from the neighbour.

Table 3.18 The proportion of farmers (%) using different water sources and the time (minutes) required for a single trip for trekking dairy cattle in the Harar milkshed

Location	Rivers or ponds	Wells (%)	Taps (%)	Estimated time required for trekking (minutes)
Urban	20	0	80	10
Rural	51	29	11	46
Highland				
Awberkaley	100	0	0	60
Deretayara	20	70	10	30
Galmashira	70	10	20	10
Lowland				
Anood	20	80	0	120
Awsharif	10	80	10	60
Barkaley	10	80	10	40
Burka	100	0	0	20
Erer	100	0	0	30
Ifadin	100	0	0	20
Kile	100	0	0	45

Regarding crossbred cattle in the rural areas, when asked their view about the crossbred cattle, farmers have expressed that they are aware of the outstanding performance of improved breeds but they do not seem to be convinced to adopt this technology at the moment. The reason for not opting to use the crossbred cattle (according to the farmers' perception) is that they feel that they are not in a position to provide the high level of management, including feeding and feed resources required by these crossbred cattle. Hence, farmers tend to opt for improving the feed environment based on ITK (indigenous technical knowledge) first, rather than the genotype of local cattle.

In the urban areas, however, some farmers use artificial insemination (AI) services provided by the regional Bureau of Agriculture, or farmers may rely on their own bulls or neighbours bulls for natural mating where AI services cannot be accessed continuously. Very few farmers raise bulls for breeding on their own farms because in the urban areas they would rather use their limited fodder available for the female stock. A shortage of replacement stock already prevails owing to low calf survival and poor reproductive performance of cows. In addition there are no breeding farms that can provide breeding animals to replace breeding stock to the dairy farms. The large farms, at this stage, are not willing to sell their female animals. They are also reluctant to dispose of their female animals, even if they are less productive. The absence of breeding farms to supply replacement stock makes it difficult to obtain replacement stock or a foundation stock, curtailing the dairy development process in the Harar milkshed. Breeding is identified as an overall constraint because of frequent interruption of AI services, so a large number of farmers are forced to have back-up bulls of inferior quality which they also use for breeding. These bulls are mostly of unknown pedigree and probably born on the farms, thus posing a threat of inbreeding or propagating undesirable traits. During the study period it was noted that three farms had already faced such a problem. Six calves were noted to have been born defective. Four were blind, one freemartin and one with an abnormally huge head were observed on three different farms. The four blind calves were on one farm while the other two were from two different farms. It should be noted that the blindness could have been caused by a vitamin A deficiency as a result of lack of green feed. Overall, 65% farmers use AI and bulls in combination, a little less than 23% use only AI and 12% use only bulls (Table 3.19). The high proportion of farms making use of both AI and natural mating may suggest the general unreliability of the AI service. Some complaints regarding veterinary services made by the farmers included sporadic interruption of the AI service, the majority of calves born through AI are males, and poor conception rate.

Table 3.19 Type of mating practiced in the urban dairy farms of the Harar milkshed

Farm groups*	Number of dairy farms	% of farms using natural mating	% of farms using AI services	% of farms using natural & AI services
Small	16	7.6	15.4	38.5
Medium	7	3.8	3.8	19.2
Large	3	0	3.8	2.8
Total	26	11.5	11.5	65.4

* Urban farms groups based on the herd size.

3.5.11 Input services

The provision of farming input is largely based on the government's support for dairy farmers in the rural areas. Apparently, the only available service in connection with the livestock is a limited service extended by the veterinary units. There is no other extension service directed to livestock production. Farmers in the rural areas were also asked to indicate the number of extension visits they have received in the preceding 12 months. They all reported no extension visits by livestock extension officers but only by crops specialists. Farmers have also pointed out a lack of efficient supply of inputs such as improved forage seeds, appropriate livestock genetic material and advice on improved but appropriate technologies.

Regarding farmers in urban areas, provision of input services has experienced changes in the last decade probably because of the policies that support growth of private enterprises, such as veterinarians and para-veterinary technicians, with the stipulation that in the long run this would enable the government to reduce its support on the provision of input services for dairy production. Most of the rural dairies obtain veterinary services from private individuals. These private technicians and veterinarians are actually government employees of the regional Bureau of Agriculture, who are working privately after hours. Generally, the results indicate that official extension services are deficient in almost all areas surveyed. Farmers in urban areas have complained about the lack of effective drugs against mastitis and the higher cost of veterinary drugs and feed resources. The absence of urban dairy associations in the region was also mentioned as an important issue concerning dairy production in the Harar milkshed.

3.5.12 Market access

Harar is a major market place for farm produce including perishable commodities such as milk, vegetables and fruits as well as a source of input and goods.

The distances of the different FAS from Harar are shown in Table 3.20, with the farthest being Anood FAS (44 km). These areas around Harar, particularly in the Harari region (Galmashira, Deretayara and Awberkaley FAS) have relatively better access to Harar market, while the ones in the Babile and Bisidimo areas have to rely heavily on emerging market outlets offered by Babile and Bisidimo. The average distance between the location of rural farmers and Harar market is about 22 km. However, distances from farms to local market centres, where input is generally obtained and where milk is sold are on average 1 to 14 km. Farmers, mainly women, deliver milk to the market centres on foot, not using donkeys or cars (See Chapter 7).

Table 3.20 Estimated distances (km) of the different locations from the Harar town

Location	Number of households	Distance
Urban	50	0.4
Rural	200	21.7
Highland		
Awberkaley	20	10
Deretayara	20	12
Galmashira	20	5
Lowland		
Anood	20	44
Awsharif	20	35
Barkaley	20	40
Burka	20	13
Erer	20	22
Ifadin	20	18
Kile	20	18

3.5.13 Milk marketing

The marketing of milk in the rural areas is more of a traditional nature. Market inaccessibility, caused by poor infrastructures (poor access to transport) or long distances, seems to have forced more home milk consumption, as noted in areas where locations exceed 14 km from the nearby local market such as the Anood, Awsharif and Ifadin FAS. However, it is important to note that these areas are the most important places that supply milk to Harar town (See Chapter 7). There are also a number of informal milk traders, agents, retailers and selfhelp (rural women milk delivery association) milk groups from the farmers that are involved in milk delivery channels. Thus, milk marketing is predominantly done through informal systems that have various forms (Discussed in Chapter 7). However, the relative importance of the different milk outlets varies widely across the locations surveyed.

The areas where farmers mainly sell to organized channels (i.e. selfhelp farmers milk association groups, retailers and agents) include the Anood, Awsharif, Barkaley, Ifadin and Kile FAS and to a lesser extent the Deretayara and Galmashira FAS. These tend to be areas where milk surpluses are high, requiring farmers to market milk outside their immediate locality. In other places like the Anood, Awsharif, Barkaley and Ifadin FAS, private traders and retailers are important. The reasons for the differences may lie in the remoteness of places. In milk deficit areas, especially those lying closer to Harar, milk is mostly sold directly by the farmers to the consumers. The differences in the distance to different milk market places in the Harar milkshed have affected the price of milk (Chapter 7). This is supported by Staal *et al.* (1999) who have shown that distance and quality of roads have marked and measurable effects on farm milk prices. They estimated that each additional kilometer of poor road between a farm and the main road, reduced the milk price received by some 35 cents per liter on the market. Poor roads like those in Ifadin FAS are also likely to reduce market prices. Agents are important determinants of returns to small-scale dairy farming and also of some market risks that farmers face. However, these agents are only important and used when they operate trustfully, because they could exploit the farmers to the extent that they cannot secure reasonable prices for their produce (milk) and get discouraged (Chapter 7).

3.5.14 Major livestock diseases

Livestock productivity is rather low in Ethiopia when compared to Africa on average. The primary constraint is feed in terms of both quality and quantity (Olaloku & Debrah, 1992; Singh *et al.*, 1997; Hanson, 1998; Irvin, 2000). The wide spread prevalence and incidence of diseases and parasites has aggravated the effect on productivity (Fisiha, 1997). The crude productivity estimates indicate that mortality is high, cattle herd offtake is low (8%) and live weight gain is low and about 20 kg per annum (FAO, 1993). In general, diseases affect cattle directly in three main ways: mortality, losses in live weight and reduced fertility (Fisiha, 1997). Epidemiology data on diseases and detailed circumstances, in which they occur, have not yet been studied and documented for the majority of places and livestock species. In Ethiopia, most of the infectious and parasitic diseases are widespread. Cattle are at risk from epidemic diseases that prevail in the country, of which the Harari region is no exception. The aim of this section of the study is to look into the most prevalent diseases which are important, in particular to dairy production in the Harari milkshed.

This part of the study was conducted on the study sites described in Chapter 2. In addition to what has been described in Chapter 2 the reader should note the following. The survey covered the epidemiology and animal health conditions on rural as well as urban dairy farms. The study was based on a questionnaire assessing the animal disease condition based on the farmers' perception. The questionnaire was prepared by the animal health group of the Agricultural Bureau of Harari regional state (M.Y. Kurtu, 2003; unpublished data). This questionnaire was structured in such a way that it would enable one to provide the various symptoms observed and perceived by the farmers. Accordingly, an inference was made by the animal health personnel to identify the possible disease. This was done in the first round and the relevant samples were collected for the detailed lab work so as to confirm the disease. In addition, the veterinarians visited the sampled urban dairy farms monthly along with the researcher, enquiring about changes in management that had occurred during the preceding month (Detail of the sampling procedure of the farms are given in Chapter 2.).

Table 3.21 shows the main disease incidences for urban and rural dairies per FAS. Black leg was found to be the major disease noted by the majority of the households (41%), particularly in rural areas causing death in extensive production systems across all the sites surveyed. Pasteurellosis was found to be of lower incidence in higher altitudes.

Table 3.21 Most important livestock diseases as perceived by the farmers in the Harar milkshed

Location	Black-leg	Anthrax	Pas-teurellosis	Internal parasite	External parasite	Mastitis	Digestion disorder	*Others
Urban	0	0	0	25	45	80	30	35
Rural	41	22	36	39	39	35	23	30
Highland								
Awberkaley	40	0	0	45	43	25	15	30
Deretayara	45	0	0	30	30	40	30	35
Galmashira	40	45	0	40	40	45	40	30
Lowland								
Anood	35	0	90	35	45	30	15	30
Awsharif	40	0	80	40	42	30	15	30
Barkaley	42	75	70	45	45	30	20	30
Burka	40	37	0	45	40	30	20	35
Erer	40	47	75	30	40	45	35	25
Ifadin	40	37	0	35	30	35	20	20
Kile	45	0	80	40	35	40	20	25

* Includes respiratory problems, difficult birth & calf pneumonia.

The distinction might be in that in the intensive systems of the highland FAS, the figure reflects the farmers' perception of the importance of the disease while in extensive systems such as the Anood, Awsharif, Barkale and Kile FAS it is related to the actual occurrence of the disease (Table3.21). The high percentage of the household reports for blackleg is mainly owing to inadequate coverage of stock inoculation as a consequence of shortages of resources, mainly the vaccine (Fiseha, 1997). The fact that urban farmers did not report infectious diseases (Anthrax, blackleg and pleuro-pneumonia) is that because this is easy disease to control through yearly vaccination of livestock. Farmers in urban dairy areas because of their close location to veterinary services; hence they may get annual vaccinations in time before the outbreak happens. The high percentage (39%) reported for parasites and particularly for mastitis (35%) may be as result of intensification of production systems and poor hygiene although the production is still low. Mastitis is noted to be an important constraint to productivity even under small-dairy systems in the milkshed. Respiratory diseases, like calf pneumonia, were found to be relatively high in Galmashira, probably owing to the prevailing cold conditions. Difficult birth and bloating were attributed to body emaciation or under-fed conditions as reported in some highland areas (e.g. Galmashira). During the discussion with the key informants mainly with the veterinarians in the Bureau of Agriculture of the regional state, it was indicated that some zoonotic diseases such as brucellosis have recently been reported in Awberkaley.

According to the bureau, the health management practices in the last year were mainly restricted to vaccination that included anthrax, parteurellosis, blackleg, contagious bovine pleuro-pneumonia and foot - and - mouth diseases, covering about 90% of the households in the surveyed areas. The use of anti-helmentics (62%) and external parasite control were reported in (80%) of the households. Applications of acaricides by hand spray were mostly used. The vaccination services thus far rendered by the regional Bureau of Agriculture were free of charge. In the future, however, the possibility of charging the farmers for this service is under consideration. For the internal and external parasite control farmers are being charged a subsidized price.

3.5.14.1 Camel diseases

According to the farmers, in 1982, 70-100% of the camel herds were attacked by a kind of diseases totally new to the farmers. This disease resulted in eliminating quite a lot of the camel herds. It was later on discovered by the farmers that the root cause of the disease was a plant locally called *Gamor* or *Gambora (Caparis tomentosa),* a noxiously poisonous plant believed to have killed a large number of camels in both Babile and Bisidimo. The plant remains green all the year round; camels tend to browse on this plant particularly during the dry season when other plant materials get dry. The symptoms of the disease as described by the farmers were as follow:

1. Set diarrhea the next day after ingestion of the poisonous plant *Gambora (Caparis tomentosa)*
2. Camel becomes recumbent and unable to stand
3. Stop eating and within a few days the camel dies.

Traditionally, farmers believe that when camels browse on *Gamor* or *Gambora (Caparis tomentosa)* plant they will get paralyses on the back bone, stop eating and will not able to stand up, remain recumbent and finally die. This is in fact mentioned as one of the most important problems for camel rearing areas and was pointed out by the farmers, during the interview, the most important cause for the decrease in the camel population in the area for the last couple of years. Apparently the concerned authorities have given no attention to camel diseases. This problem was identified as the most important aspects of livestock production particularly camel herds in the Babile and Bisidimo area.

The increased occurrence of poisonous plants may indicate changes in the ecology of the area. It is worth following up this aspect by a more in depth investigation.

3.5.14.2 Traditional treatments for Gambora (Caparis tomentosa) poisoning

Feeding the sick animal with sheep fat or fat from a large intestine of cattle is claimed to be remedial to the disease caused by the poisonous plant *Gambora* (*Caparis tomentosa).* A soup made from these fat sources, when drenched about (5-10 liter/day) for one month to the sick/ poisoned animal, would lead to recover after one month, with the exception of heavily pregnant camels which usually die. This may be due to the fact that the fatty substances are probably binding to the poison and may prevent further absorption. This treatment also results in the dehydration of the animal improving its general health and promoting the excursion of the toxic substances out of body through urine.

3.5.14.3 Camel influenza

This is also one of the most important diseases of camels that attack all age groups almost once or twice a year. The disease is locally called *Gorer duy duf.* It causes an inflammation of the nasal cavity and a running nose, resulting in difficult breathing and severe cases in suffocation of the animals. Fever is mostly apparent, the disease is usually fatal and no treatment is locally available.

3.5.14.4 Shimbere

This is also an important camel disease, resulting in blindness of the animal, causing camels to go blind, a twisted neck and eventually death. The disease is acute if a twisted neck manifests but if the animal lacriminates it leads to blindness or madness. The cause has not been identified and the treatment cannot be provided locally.

3.6 PROSPECTS FOR URBAN DAIRY DEVELOPMENT AND CONSTRAINTS IN THE HARAR MILKSHED

The existence of enormous demand-supply variance in milk products for Harar city shown in the preceding sections indicates that potentially there exists quite good opportunities for development of urban dairy in the Harar milkshed. Large-scale dairy farms and small urban dairy have the potential to minimize milk shortages in the Harar city. Market oriented dairy systems could be one of possible means of achieving intensive dairy systems. It may play an important role in providing diversity of milk products and quality products as well to the city which currently seems to be lacking in the city. It also means that a well managed small dairy farm could also contribute to improvement in household nutrition and health, improvement, family income, food security and natural resource management and may be nutrient cycling. These system has to be encouraged to ensure the desired goal of food self sufficiency and meeting the milk requirement of urban consumers. However, the system is not without problem and some of the problems need to be addressed as outlined below.

The major limitations, as perceived by the farmers during surveying, for the development of urban and peri-urban dairy production are shown in Table 3.22.

Out standing problems identified were feeds and feeding, shortages of water, milk marketing, animal diseases and health services, and others respectively. Some of these problems specially feeds and feeding systems, shortage of water as well as milk marketing have to be addressed and requires an in depth study and understanding so as to come up with a viable solution to promote and ensure the dairy development of urban dairy production systems in the regions

Table 3.22 Ranking order of constraints as perceived by farmers in the Harar milkshed in 2001/2002

Constraints	Ranking assigned by the farmers					
Farmers N=(50)	1	2	3	4	5	6
Feeds and feeding	87	13	0	0	0	0
Breeds and breeding	11	22	44	12	5	6
Animal diseases and health services	13	66	21	0	0	0
Milk marketing	41	23	13	16	0	7
Water shortage	49	25	15	11	0	0
Shortage of land	13	14	26	25	22	0
Others*	36	24	15	18	0	7

* This includes, none technical problems like government policies, the need of establishment of farmers dairy association, training and price regulation for in-puts mainly feed, veterinary drugs and related issues.

CHAPTER 4

CHARACTERISATION OF THE EXISTING DAIRY PRODUCTION SUB-SYSTEMS WITHIN THE HARAR MILKSHED

4.1 INTRODUCTION

A clear understanding of the characteristics of the dairy production systems within an area or a milkshed is required to develop appropriate interventions, identifying associated problems that can be researched and subsequently identify those farming groups that should be targeted for assistance. In this way relevant interventions can be prescribed according to their specific needs rather than using blanket recommendation (Gockowski & Baker, 1996).

For the Harar milkshed this means a detailed knowledge is required of the specific characteristics of the different dairy production systems in this milkshed. The preceding chapters have shown that the general characteristics that describe the dairy production systems of the Harar milkshed vary greatly depending on the location of the farm. The variation occurs not only in dairy technologies used, such as feeding strategies, husbandry practices and breeds used for milk production but also for the household characteristics and access to markets. Therefore, a further characterisation of the sub-systems or clusters was required based on their common denominators in terms of natural and human resources, constraints and the access to markets. Appropriate interventions in terms of both research and development strategies for dairy production should consider all these factors and the complex relationships and patterns among them as suggested by Staal *et al.* (1997).

4.2 MATERIALS AND METHODS

In order to group the different households or dairy producers within the Harar milkshed into different clusters, a group of variables needs to be identified through the principal component analysis. The aim of this part of the study was to identify and characterise the different dairy sub-systems within the Harar milkshed using cluster analysis.

The use of the principal component analysis method is motivated or justified by the need to reduce the number of variables included in the cluster analysis without omitting potentially important variables. The key to the application of this method to small-scale dairy production is the use of a wide range of variables, related to dairy production, household resources and market access (Staal *et al.*, 1999).

The variables identified in the principal component analysis were used for cluster analysis. These variables were considered important to characterise the household resources available for dairy production in general and to the household in particular (Staal *et al.*, 1999).

The principal component analysis was employed to identify major factors contributing to the variability in the dairy production systems of the Harar milkshed. Principal component analysis was carried out on the correlation matrix generated from the original variables to characterise the dairy production systems. Accordingly, variables with individual contributions greater than 2% of the total variance in the rural and 5% for the urban dairy production systems were identified.

Actual analysis was carried out separately for the rural and the urban components of the Harar milkshed. The major variables identified in the principal component analysis were used in the cluster analysis. Euclidean distance estimates were computed from the variables identified.

$$D_{ij}=\sqrt{\left\{\sum_{i=1}^{p}\left(X_{ik}-X_{jk}\right)^{2}\right\}}$$

Where Dij = Euclidean distance from individual "i" to "j"

Xik =the value of variable Xk for individual "i"

Xjk = the value of variable Xk for individual "j"

P= variables $X_1, X_2 \ldots Xp$

Cluster analysis was based on the Ward's minimum variance linkage type procedure Staal *et al.* (1997). All statistical computations were carried out using the statistical software package SPSS version 10.

The number of clusters in both the rural and the urban production systems was determined based on the mean Euclidean distance which gave a co-phonetic correlation coefficient greater than 75%. The results were compared and interpreted to differentiate the observations along the desired axes (Staal *et al.*, 1997).

4.3 RESULTS AND DISCUSSION

A selection of aspects discussed in this study is shown in Chapter 9 (Compilation of photographs).

4.3.1 Principal component analysis

Eight variables that contributed about 55.7% of the total variance in the rural dairy production system were selected. The variables considered as important differentiating characteristics of the different dairy production sub-systems in the rural areas were: the gender of the household head (20.8%), the total land area (8%), the area of grazing land (5.8%), the number of cows (6.2%), the total TLU (3.9%), the relative distance from the market (4.6%), family size (3.9%) and crop land (2.6%).

Six variables contributing about 78% of the total variability in the urban dairy production systems were also identified. These included: the cattle herd size (38.9%), the gender of the household head (11.9%), land size (8.6%), level of education (6.4%), number of cows (9.3%) and off-farm business (5.6%).

4.4 CLUSTER ANALYSIS OF THE HARAR MILKSHED

4.4.1 Rural dairy production sub-systems

Households in the rural areas surveyed fell into four clusters (Table 4.1) based on the results of the cluster analysis.

The majority of the rural households surveyed fell into Cluster 1, named the Traditional Intensive Dairy (TID) farmers (3%) and Cluster 2, named the Traditional Semi-intensive Dairy (TSID) (40%). Households in Cluster 3, named the Traditional Extensive Dairy based on Extensive Agro-pastoral systems (TAD) and Cluster 4, named the Traditional Extensive Agro-pastoral Dairy (TEAD) constituted about 7% and 23% respectively of the rural households surveyed (Table 4.1). Households in Clusters 1 and 2 had smaller areas of land and smaller cattle herd sizes compared to households in Clusters 3 and 4. Households in Cluster 1 did not have grazing and had smaller crop lands than the other three clusters. Despite the small crop areas, households in Cluster 1 had larger quantities of crop residues than Clusters 3 and 4. This larger quantity of crop residues produced in Cluster 1 is attributed mainly to the higher amount of rainfall received compared to the other two clusters.

Table 4.1 The most important characteristics of the four rural dairy production sub-systems in the Harar milkshed

Clusters/dairy systems	(1) Traditional Intensive dairy (TID)	(2) Traditional Semi-intensive dairy (TSID)	(3) Traditional Agro-pastoralist dairy (TAD)	(4) Traditional extensive Agro-pastoralist (TEAD)
n= household	60	80	45.0	15.0
% of households	30	40	22.5	7.5
Farming characteristics				
Farm size (ha)	1.3 ± 0.9	4.2 ± 1.5	8.0 ± 2.1	7.2 ± 0.2
Crop land (ha)	1.3 ± 0.9	3.1 ± 1.5	5.6 ± 2.1	4.5 ± 0.2
Cereals (ha)	1.0 ± 2.0	1.3 ± 0.5	3.6 ± 0.8	3.2 ± 0.8
Grazing (ha)	0	1.1 ± 0.7	2.4 ± 0.5	2.7 ± 0.8
Cattle herd size (animals)	4.3 ± 2.0	7.5 ± 3.8	5.8 ± 3.7	27.9 ± 12.8
Total TLU	3.9 ± 1.6	8.2 ± 6.3	8.5 ± 4.2	22.2 ± 8.2
Chat (ha)	0.2 ± 0.7	0.3 ± 0.4	0.4 ± 0.8	0.1 ± 0.8
Groundnut (ha)	0.7 ± 0.6	1.5 ± 0.8	1.6 ± 1.1	1.2 ± 0.5
Crop residues (kg)	3950 ± 1600	4900 ± 560	420 ± 80	410 ± 80
Grazing (ha/TLU)	0.1	0.4	0.1*	0.2*
Crop residues (kg/TLU)	0.6 ± 0.6	0.1 ± 0.6	0.0 ± 0.8	0.4 ± 0.8
Total milk production (l/d)	3.0 ± 1.5	3.2 ± 1.1	2.9 ± 1.0	7.9 ± 6.0
Total Milk (l/TLU/ha)	0.6	0.1	0.0	0.0
Household characteristics				
Female headed household (%)	10.0	9.0	4.0	2.0
Total family size	7.7	7.1	8.9	11.0
Marketing characteristics				
Distance from Harar (km)	9.7 ± 2.9	22.0 ± 8.8	35.8 ± 6.5	41.5 ± 2.2
Distance from market centers (km)	9.7 ± 2.9	12.5 ± 2.8	14.0 ± 3.5	18.0 ± 2.9
Availability of extension services (%)	75	25	15	15
Participation in milk association (%)	50	85	95	95
Average milk price (Birr/l)	2.4 ± 0.9	1.9 ± 1.0	1.8 ± 0.8	1.7 ± 0.7
Average milk sold (l/d)	1.4 ± 1.1	1.6 ± 0.9	1.9 ± 1.1	4.2 ± 1.0
Average milk consumed (l/d)	1.5 ± 2.0	1.5 ± 2.3	1.0 ± 0.0	3.6 ± 1.0

**Extensive rangeland used for communal grazing was not considered.

Total milk production per day was the lowest in Cluster 1 and highest in Cluster 4. The latter probably owing to the larger herd size and number of cows available in Cluster 4. The quantity of milk consumed and sold per day followed the same trend. It was lower in Cluster 1 and higher in Cluster 4. However, the average price for milk sold followed an opposite trend. It was higher for the households in Cluster 1 and lower in Cluster 4. The higher milk consumption and the lower price of milk for the households in Cluster 4 can be explained by the longer distances involved from the market centers and lack of access to the markets or lack of direct sales of milk to the consumers compared to the households in Cluster 1. This indicates that market access is probably the most important variable determining milk price. Access to markets is believed to stimulate dairy producers to increase production in the Harar milkshed, a finding that is supported by Staal & Shapiro (1996) who studied the Addis Ababa milkshed.

As seen from the preceding description of the survey results, there is considerable variation in the level of intensification of dairy activities between households. The level of intensification is higher in Cluster 1 and lower in Cluster 4 (Table 4.1).

4.4.1.1 Distribution of households of the rural areas per cluster

A frequency distribution is presented in Table 4.2 of the rural households per cluster in the different classes of milk production potential (high, medium or low) as determined by resource availability and access to markets (see Table 2.2 in Chapter 2).

These criteria to define milk production potential and market access were used to select districts surveyed and based on the opinion of expert informants and secondary data. This shows that almost all areas of milk production potential with different levels of access to markets have been included in the samples studied as was anticipated when the sampling procedures were designed for the study area.

Forty percent of households surveyed were engaged in the semi-intensive dairy production systems with a relatively medium and low milk production potential and high and low market access. This indicates that the sample was skewed towards semi-intensive systems. It is thus apparent that relatively low levels of these factors are related to the combination of traits found in Cluster 1. Low access to services (extension, including veterinarians) and small land holdings were important factors determining the status of a farm for classification. A reasonable proportion of the households (30%) of Cluster 1 in the rural dairy production systems are found mainly in areas of high and medium milk production potential with equal market access, which is in line with the peri-urban nature of their activities in zones close to relatively high rainfalls.

Table 4.2 Number of observations and the percentage of rural households per cluster per class of milk production potential in the Harar milkshed

Milk production potential	**High**		**Medium**		**Low**
Access to market	High	Medium	High	Medium	Low
Intensive	20	20	0	20	0
Semi-Intensive	0	0	60	0	20
Agro-Pastoralist	0	0	0	6	39
Extensive Agro-Pastoralist	0	0	0	7	8
Total	20 (10%)	20 (10%)	60 (30%)	33 (17%)	67 (33%)

Extensive agro-pastoralist households (7%) are found mainly in areas of low production potential and low access to markets. The extensive agro-pastoralists are in the same zone with agro-pastoralists and may simply represent a more extensive land and more cattle of semi- pastoralist form of production. The results therefore show clear patterns of farm types and intensification strategies in different combinations of the two main determining factors.

A group of variables was also selected to measure the farms access to markets. These included distance of the farm to Harar, the availability of local extension services, the farm gate price of milk received by the farmer, co-operative membership (traditional milk association), and milk sales to informal market outlets (Table 4.1). The study showed that government veterinary and extension services were not in place in most of the surveyed rural areas.

The absence of formal outlets or opportunities to direct milk sales to the consumer and even to milk retailers are indicators of a lack of market development as a result of low market access. Co-operative memberships of traditional milk associations are not indicative of access to both input and output markets because the co-operatives (traditional milk association) do not offer any veterinary or extension services and do not provide secured milk sales to the members.

Females as the head of the household have little access to resources, including formal credit facilities. Off-farm businesses of household members tend to affect the labour for dairy, but may also increase the household income. Total land and herd size were also considered as indicators of wealth. Dependents of the household and its size may affect household milk consumption and the availability of household labour.

4.4.1.2 General characteristics of the rural dairy production sub-systems

Clusters 1 and 2 represented most of the rural households and Clusters 3 and 4 the smallest. In the rural areas Cluster 1 had the second largest group of farmers (30%) and compared to the rest of the dairy production systems it had the smallest land holding (1.32 ha). They operate a relatively intensive system of crop-livestock farming and depend more on cash crops particularly *chat* for their income. They have better access to multiple market outlets and sell milk directly to the consumer.

The households in Cluster 1 apply zero-grazing and a cut-and-carry system as the main form of feeding the cattle. Because of the close distance to Harar, there are only a few females (less than 20%) that participate in milk group associations, compared with much higher proportions among other farmers. They receive the highest price (Birr 2.5/l milk) for their milk, which may be related to the fact that they are the closest to Harar. About 6% of the farms or households are headed by females. Given these characteristics, they are considered to be the Traditional Intensive Dairy (TID) farmers.

Cluster 2 is composed of the largest group of households with a larger cropland holdings (3.1 ha), but who grow more cereals, feed more crop residues and practise a little more grazing than those in Cluster 1. Milk yield, however, is as low as Cluster

1. They are closer (22 km) to Harar and about 85% of them are members of the traditional milk association groups. Almost the same as with Cluster 1, about 6.5% households are headed by females. The Traditional Semi-intensive Dairy constitute 40% of the dairy production systems surveyed.

Cluster 3 comprises of those households who have a relatively large crop land resource (5.2 ha) and grazing land (2.4 ha), who practise extensive grazing, although they also feed crop residues. They also have a larger total TLU than Clusters 1 and 2. Their income seems to depend on milk sales and tend to rely more on milk association groups to market their milk. They can be referred to as Traditional Agro-pastoral Dairy (TAD)/ system. All three these groups (Clusters 1, 2 and 3) have unimproved local cattle breeds and practise traditional husbandry and farming systems.

The households in Cluster 4 are distinguished by a large (>27 cattle) herd size or total TLU and with almost the same size of land but slightly more (>2.6 ha) than farmers in Cluster 3. Almost all depend on milk association groups to sell their milk. They are furthest (>40 km) from Harar and receive the lowest (<Birr 1.8/l milk) price for their milk. The milk production per cow day is low, but higher than the other clusters in terms of total milk production per day because of the larger herd size they possess. Although it was not actually determined in this study, milk sales probably contribute significantly to the household income compared to other agricultural practices. It is an aspect that should be followed up because it may have very important implications in the future development of the dairy sector.

4.4.2 Urban dairy production sub-systems

The variables used to indicate the level of intensification of dairy production systems, including the relative use of feeds as input and volume of milk production as an output in the urban dairies of the Harar milkshed are shown in Table 4.3.

The most important characteristics of the households in the urban dairy production sub-system of the Harar milkshed are also presented in Table 4.3. Twenty five percent of the urban dairy households were headed by women. Of this the higher proportion (20%) were found in Cluster 5 (URP), 5% in Cluster 6 and none in Cluster 7 (SPUD). The number of the household heads engaged in off-farm activities was

42%. The higher proportion of household heads that engaged in off-farm activities was in Clusters 6 and 7 (100%) and a lower percentage was observed for farms in Cluster 5 (58%).

Table 4.3 The most important characteristics of the three urban dairy production sub-systems in the Harar milkshed

Cluster	(5) Urban resource poor farms (URP)	(6) Resource medium dairy systems (URMDS)	(7) Specialized peri-urban dairy (SPUD)
N = household	35	11	4
% of households	70	22	8
Farming characteristics			
Land size (ha)	0.3 ± 0.8	0.5 ± 1.1	4.0 ± 5.4
Cattle herd size (animals)	12.0 ± 2.3	21.0 ± 4.1	63.0 ± 22.2
Total TLU	8.4 ± 2.4	14.7 ± 3.2	44.1 ± 15.0
Number of cows	4.9 ± 2.2	11.1 ± 3.5	33.2 ± 4.1
Number of lactating cows	3.5 ± 1.8	7.8 ± 2.0	23.5 ± 9.9
Hay purchased (Birr/TLU/year)	1301	2342	16960
Brewery by-products purchased (Birr/TLU/ year)	4043	6447	27557
Fodder purchased (Birr/TLU/Year)	79	499	3837
Household characteristics			
Age of the household	54.1 ± 10.0	54.9 ± 6.8	43.3 ± 14.0
Female headed household (%)	10	3	0
Total family size	6.8 ± 1.8	7.6 ± 1.8	9.2 ± 3.2
Household off-farm activity	27	11	4
Distance from Harar market (km)	0.3 ± 0.8	0.8 ± 1.5	8.3 ± 12.6*
Average price for milk (Birr/l)	2.5 ± 0.1	2.5 ± 0.1	2.5 ± 0.1
Milk production (l/d per cow)	5.7 ± 2.9	5.9 ± 2.0	5.6 ± 0.8
Average milk sold (l/day)	14.9 ± 8.0	46.7 ± 12.0	87.0 ±26.0

* Mean distance was inflated owing to the inclusion of Bisidimo dairy farm which is located about 21 km from Harar.

4.4.2.1 General characteristics of the urban dairy production sub-systems

The cluster analysis from the 50 urban households surveyed showed that there are three dairy production sub-systems that can be identified in the urban areas of the Harar milkshed, designated as Clusters 5, 6 and 7.

Farmers in the urban area falling in Cluster 5 (URP) have a very small land size (0.3 ha) and no grazing but they buy a little fodder (less than Birr100/year) (Table 4.3). These dairy farms are intensive production units based on zero grazing of crossbred and high grade cattle. They may plant a small amount of Napier grass in the back yard or as a fence. These households normally rely on the feed sources coming to the market from the surrounding rural farmers. Usually they rely heavily on the non-conventional feed resources including local brewery by-products produced in that locality. They have the smallest herd size (3 to 4) and are mostly dependent on family labour. Most of the farmers in this group are retired civil servants from military forces and by virtue of their low income they can be classified in lower income groups. With the above characteristics, they can be described as urban resource poor (URP) group of farmers. These farmers comprise 70% of the dairy farms surveyed in the urban areas and are the largest group.

The second largest group Cluster 6 (URMDS) is composed of farmers with a slightly larger (11) herd size, but they purchase more fodder and other feedstuffs. These dairy farms are based on stall-feeding and crossbred or high grade cattle of Holstein type. Milk yield is almost the same as for Cluster 5. These households consist mostly of civil servants with better incomes than those in Cluster 5. The dairy business may be considered as a part-time activity for a supplementary source of income but not as a baseline business and comprised 22% of the urban dairy farms surveyed. Given these characteristics these farmers can be classified as Cluster 6 (URMDS).

The last group of farms in Cluster 7 (SPUD) is distinguished primarily by a larger (4 ha) land size and 98% more fodder is purchase than for Cluster 5. Most of these farms are located on the periphery of the town. The majority of the farmers have additional off-farm businesses like hotels, grain stores and pharmacies which are generating more income than dairy farm business. Almost all farms have improved housing (hollow-blocks, roofed and concrete floor) for cattle, and related facilities, i.e.

hay barns, feed stores and even a reservoir made of concrete. Generally they use specialised input including improved genotype and artificial insemination. These are some of the characteristics of specialized diary production in Cluster 7 (SPUD) and produce about 200 liter milk per day. Similar studies were conducted (Tegegne *et al.*, 2000), characterising the Addis Ababa area of dairy systems where seven dairy production system groups were identified. These were: Traditional crop/livestock farms in rural areas; Intensified dairy/crop livestock farms; Intra-urban dairy farms in Addis Ababa; Crop/livestock with intensive cropping; Specialized dairy farms; Peri-urban dairy farms and Urban dairy in secondary towns. Some of these groups tended to be similar, such as peri-urban, intra-urban and specialised ones.

In the rural areas studied by Tegegne *et al.* (2000) it appears that only those farmers who were using the improved technologies or improved input such as improved genotype, feeds and feeding and AI were combined. However, in the current study the use of all those input are totally unheard of in the rural areas of Harar milkshed, thus, dairy productions are based on purely traditional husbandry systems.

Farm/household resources, such as labour, may be critical for intensification of dairy farming where dairy farming requires labour not only for a cut-and-carry feeding system, but for the overall management activities such as herding, cattle housing, feed and other input.

Intensification of dairy production is related to feed input per animal and the output of milk in urban while in the rural areas is related to the land available (ha) as input and milk (liter) as out put respectively.

CHAPTER 5

FEED RESOURCES IN THE HARAR MILKSHED

5.1 INTRODUCTION

Dairy production systems in tropical and sub-tropical Sub-Saharan Africa are diverse. Generally, five dairy production systems have been identified: pastoralism, agro-pastoralism; crop-livestock mixed farming; intensive dairy farming; and peri-urban dairy farming (Nell, 1992). Rey *et al.* (1993) defined peri-urban dairy production systems as being involved in production, processing and marketing of milk and milk products that are channeled to urban centers. This is a new and emerging form of dairy production in and around Sub-Saharan Africa cities trying to meet the growing demand for milk and milk products in the urban centers.

The results from a survey among 250 rural dairy producing households presented in the previous chapters indicated that the major constraint for dairy production is an inadequate feed supply, both in quality and quantity, in almost all production systems. This has been well recognized by a number of studies in the tropics (Olaloku & Debrah, 1992; Singh, 1997; Hanson, 1998; Irvin, 2000). Nsahlai *et al.* (1996) and Leng (1999) reported that natural grass and crop residues form the major feed sources for ruminants in most developing countries in the tropics. In the crop-livestock production systems, the livestock heavily depends on crop residues in what is generally called a cereal/livestock farming system and stubble grazing (Goshu *et al.*, 1989).

Rural dairy production in the Harar milkshed is characterized by the traditional features of husbandry practices using the local multi-purpose cattle, while the urban and peri-urban dairy production systems rely mostly on genetically improved (crossbred) dairy animals with the objective to increase milk production. However, the anticipated increased milk production will only be realised if corresponding improvements are made in the management practices, particularly in the feeding of the improved cows. It is therefore necessary to evaluate the current feed sources and the feeding practices of the various dairy production systems.

Knowledge of the relevant information pertaining to the available feed sources, feeding practices and chemical composition of the feedstuffs would enable extension officers and other support services to advise the dairy farmers of the Harar milkshed on improving the productivity of their dairy herds.

The aim of this part of the study was to identify and document the major feed sources available for milk production and determine how these resources are being utilised by different farming systems within the Harar milkshed. Where applicable, suggestions and recommendations are made for improved utilization of feed resources as well as research to be conducted.

5.2 MATERIALS AND METHODS

Descriptions of the study area as well as the procedures used for feed sample collection and laboratory analysis have been presented in Chapter 2. Information and data obtained from the survey part of the study were used for the inventory of feedstuffs and identification of feed types used in the rural and urban dairy production units. Results from the survey and various indirect methods obtained from literature for estimating the amount of feed available were used to estimate the quantity of the feed available. These estimates were compared to the quantity of feed required for maintenance in the rural dairies as described by Hunting (1976).

Feed requirements for maintenance and biomass yield of grass and bush (560 kg DM/ha) were estimated using the procedures described by Hunting (1976). The DM yield/ha for low feed value crops were estimated from the information provided by WARDIS (1997).

Data on groundnut biomass was obtained from the Babile Research Station, Alemaya University (2002, unpublished data). Sorghum and maize residue yields were calculated based on the ratio of grain to residue (1:0.6) according to Anderson (1987). Fifty percent of the crop yields were used as basis to estimate yields from thinnings according to Anderson (1987). Estimates for the weeds were taken as 42% of the crop residue according to de Leeuw (1997). The total Tropical Livestock Units (TLU) of the herds were calculated according to ILCA (1993). Total annual feed requirement were estimated at 2 218 kg DM/TLU (Bruk, 2000).

5.3 RESULTS AND DISCUSSION

A selection of aspects discussed in this study is shown in Chapter 9 (Compilation of photographs).

5.3.1 Inventory of feed resources in the rural areas of the Harar milkshed

In the rural areas five major feed sources were identified. These were natural pastures, maize and sorghum thinnings, weeds and crop residues from sorghum and maize production, groundnut residues and other supplementary feeds like cactus and household waste.

The distribution of the feed sources used by small-scale dairy farmers in the rural areas of the Harar milkshed is shown in Table 5.1.

Table 5.1 Distribution of the major feed sources used by the rural farmers in the Harar milkshed

Feed source	Number of farmers	Percent of the total
Natural pasture*	143	72
Thinning products and weeds	200	100
Industry by-products	3	2
Crop residues	200	100
Minerals	41	21
Others (supplementary)	100	50

* Utilized as grazing and/or cut-and-carry systems.

About 72% of the rural livestock make use of natural pasture. These pastures were found to be used in different forms, i.e. in the highlands it is mostly used in cut-and-carry systems and in the lowlands it is mostly grazed. The remaining 28% of the rural farmers did not have natural pastures available. Almost all farms surveyed were using crop thinnings, weeds and crop residues. Mineral supplementation was provided by only 20% of the farmers. Almost half of the surveyed rural households supplemented their animals with feedstuffs that included cactus, grain by-products from household waste including bran from maize and sorghum home milling, especially during the dry seasons. No agro-industrial by-products were used in the rural areas surveyed. Mineral supplement sources included common salt, various soils, crushed rocks and lake soils or water from wells. Except for the common salt, very little is known about all the remaining mineral sources and their mineral content and value as feed sources. Thus, this is an area that requires urgent attention in future research.

5.3.2 Availability of feed resources in the rural areas

Estimates of the available feeds (DM), the TLU's of the households and the feed requirement s of the rural areas per FAS in the Harar milkshed are shown in Table 5.2.

Table 5.2 The total Tropical Livestock Units (TLU), estimates of availability of feedstuffs and the feed requirements of the households per FAS in the rural areas of the Harar milkshed

Location	Total TLU*	Feed require-ment (kg DM)	Available feedstuffs (kg DM)						
			Private grazing	Thinnings	Weeds	Residues sorghum maize	Ground -nut	Communal grazing/cut -and-carry	Total
Highland									
Awberkaley	3.3	7400	1260	140	370	990	0	6720	9389
Deretayara	4.2	9250	560	200	520	1240	0	5000	7520
Galmashira	4.3	9450	0	140	370	910	0	2800	4219
Lowlands									
Anood	15.3	33950	1460	230	600	1440	3000	14560	21280
Awsharif	11.5	25390	1480	230	620	1470	2550	14560	20910
Barkaley	10.2	22710	1480	260	700	1620	1650	14560	20260
Burka	6.5	14480	0	100	260	630	1500	3360	5840
Erer	4.9	17300	0	090	230	570	050	3360	4300
Ifadin	10.1	22460	0	076	190	470	680	14560	15970
Kile	7.1	15660	1200	076	190	460	1440	11200	14560
Average	7.7	17805	744	154	405	980	1087	9068	12425

* Coefficients for estimating TLU = Adult cattle 0.7; Sheep & goats 0.1; Donkeys 0.5; Camel 1.0; Weaner cattle = 0.5; Sheep and goats 0.07; Suckling animals = Cattle 0.2; Sheep and goats 0.03 (ILCA, 1993).

The overall mean TLU per household for the rural areas was 7.74 (Table 5.2), which is higher than the minimum required for subsistence (4 to 5 TLU/household) as suggested by Breman & de Wit (1983). This is probably due to the inclusion of the lowlands (Agro-pastoralists), which normally have a greater number of livestock than the highlands per household (DPPD, 1998). The total feed requirement for maintenance was estimated as 17 805 kg DM/year per household, while the estimated total feed available was only 12 425 kg DM/year per household. This suggests that there is a 30% deficit in livestock feeds per household/year. The major feed source for livestock was grazing. The grazing areas for the lowlands represent the natural rangeland, while for the highlands it represent forage, particularly for those using zero-grazing. These forage include various sources, such as roadsides, riverbanks and borders of crop fields that are mainly used for cut-and-carry systems. However, estimates for the potential of grazing areas, particularly for the lowlands could have been overestimated, because only the potential yields and not the actual yields are published. These rangelands consisted of overgrazed areas with various degrees of soil erosion, containing various grasses, bushes, shrubs and cactus. Cactus pear (*Opuntia ficus*-indica) has the following chemical composition: 21.3% DM, 17.3% ash, 82.7% OM, 13.3% CP, 0.26% P and 3.8% Ca, with an IVOMD of 65.4% (Knoses, 1977). As cactus is a commonly used feed, it is urgent to determine its nutritional value and productivity under Ethiopian conditions. Farmers mentioned during the interviews that they face severe feed shortages almost continuously. Especially in the dry season they are forced to apply various strategies depending on the severity of the shortage. These strategies include efforts to sustain livestock on various non-conventional feeds like shrub *Lantana camara* (that remain green all-year round) and leaves of cactus pears (*Opuntia ficus-indicus)* and as a last resort the stock is moved to other places when the situation gets worse.

Lantana camara is a well known toxic plant, causing photosensitive skin reaction and liver damage (Van Wyk *et al.*, 2002). This cactus has spines that injure cattle in their mouths and may subsequently reduce feed intake and milk yield also drops. When the dry season is prolonged, farmers normally move their livestock to other places in search of better pasture and water. This supports the finding that the estimated quantity of feed resources is not enough to meet the requirement of the animals. In addition, during the transect walks (inspection visits, as part of the Participatory Rural Appraisal) after the farmers have been interviewed, it was noted that the rangeland was degraded with only scattered trees in most places, especially in Barkaley and Anood FAS. These areas are often affected with recurrent droughts and famine. In fact, most of the farmers interviewed were from these areas and came mainly to collect some grains from the relief and rehabilitation station in the area. It was further noted during the discussion sessions with the key informants that these farmers were very poor and supplement their daily livelihood by collecting firewood and making charcoal. As a result, deforestation aggravates land degradation and soil erosion problems in the area. Almost similar conditions were observed in other rangeland areas of Ethiopia, including Borana and Afar (Bruk, 2000).

Considering the contribution of each feed source to livestock feeding, natural pastures contribute about 81% to the total DM intake and crop residues 15%, followed by weeds and thinnings at 4%. However, the contribution of each feed component in various locations would vary. Similar observations were reported from the central highlands of Ethiopia by Abate *et al.* (1993) who estimated that pastures contributed 50% of the total livestock feed intake, followed by crop residues. Recent estimates show that cereals and pulses produce residues and stubble grazing that contributes more than 90% of the available feed in the highlands (De Leeuw, 1997). All feedstuffs are produced on farm and none was purchased by farmers in the rural areas.

Two important feed resources included in the current estimates are the thinnings and weeds that normally come from sorghum and maize crops; starting from an early stage (at knee height) until harvest. The thinnings are usually estimated at about 50% of the biomass production for sorghum and maize (Anderson, 1987). However, Wibaux *et al.* (1986) reported that farmers in and around Harar purposefully use high seeding rates for sorghum and maize production to enable them to have as much thinnings as possible and to have higher biomass yields for animal feeding from their crop lands. They have reported that in order to get thinning products for their animals, farmers in the Harari region and its surrounding areas start the season with stands of 170 000 to 300 000 plants for sorghum and maize/ha, and progressively lower this density to 30 000 to 45 000 plants/ha at harvest (Wibaux *et al*, 1986). These authors reported that farmers thin sorghum and maize from about 5 to 6 weeks after emergence for use as animal feed.

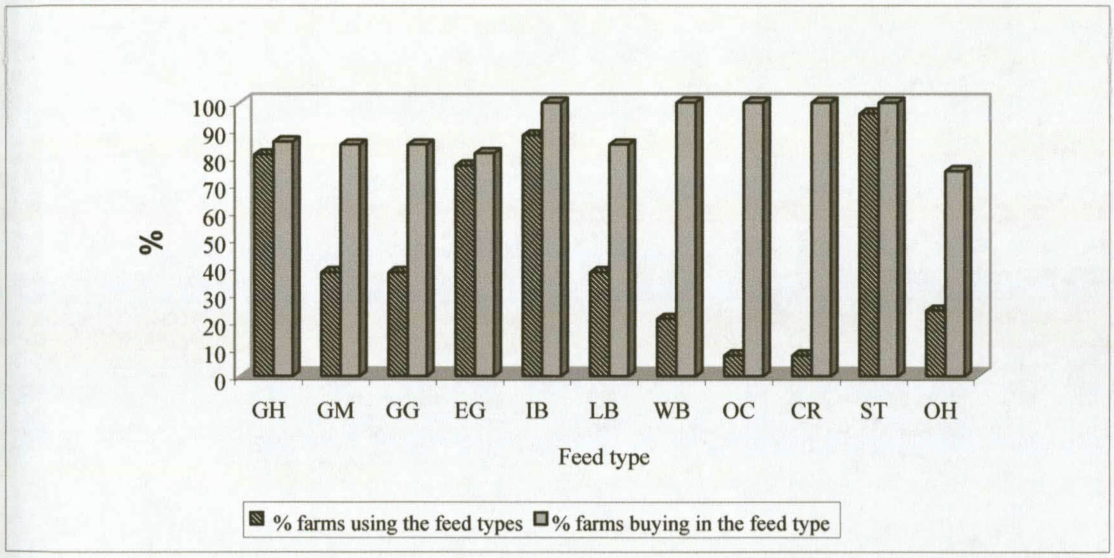
Nonetheless it appears that there is a serious shortage of feeds to balance animal requirements in all the rural locations surveyed in this study. It is noteworthy that no hay making practices were observed in all rural areas surveyed, including the highlands. This may be owing to a lack of sufficient quantities of material to harvest from the wet season, although the shrinkage of land holdings over time may also have played a role in the loss of the skills of hay making. However, it seems that this deserves further research consideration in the future. The long-term effects of such intensive exploitation of crop land in order to produce thinnings for livestock is also an important topic to be researched.

5.3.3 Feed resources used in urban dairy farms

Although eleven different livestock feed types were identified in the urban dairy production systems, these were categorized into six feed types namely: pasture/roadside, grazing/cut-and-carry, hay, crop residues, concentrates and non-conventional feeds. Grazing around roadsides is practiced by a few (6%) peri-urban and urban dairy farms.

The majority (94%) of the small-scale urban dairy farms practise zero-grazing. A similar finding was reported by Staal & Shapiro (1996) for the urban dairy sector of Addis Ababa. This is primarily due to a shortage of areas for grazing in urban areas and zero-grazing or stall feeding is widely practiced. The roughages used include grass hay (GH), green grass (GG), green maize (GM), elephant grass (EG) and crop residues (CR) (Figure 5.1). The concentrates include industry brewery wastes (IB), wheat bran (WB) and oil cakes (OC). The non-conventional feeds used are local brewery waste (LB) and other feeds (OH) that include a miscellaneous of feedstuffs mainly flourmill waste (Figure 5.1). Industrial brewery waste (IB) is used by 88% of the urban dairy farmers, grass hay (GH) by 81%, elephant grass (EG) by 77% and green maize (GM) by 38%.

Crop residues (CR) are used by only a few (6%) farms. The availability of some of the forages such as green maize stalks, green grasses and elephant grass is seasonal and these forages are available from June to October. Cereal by-products including wheat bran (WB) and oil cakes (OC) are used by 21% of the urban dairy farmers. Salt (ST) is used by almost all (96%) the farmers surveyed. There are other feedstuffs that include non-conventional feeds like flour mill waste (OH), local brewery waste (LB) (locally called *Atela*) and household (kitchen) waste. The local brewery waste (LB) is a by-product of the homemade beer and other alcoholics drinks. These are usually based on barley, maize and sorghum depending on the localities and the seasonal availability of these cereal grains. The non-conventional feedstuffs is used by a considerable proportion of farmers (23%), except local brewery waste which is used by more farmers (38%). However, these non-conventional feedstuffs are important feed sources, especially for small-scale farmers in urban areas. This indicates that farmers are trying to exploit all available feed material to meet the requirements of the dairy animals.



Where GH = grass hay; GM = green maize; GG = green grass; EG = elephant grass; IB = industrial brewery waste; LB = local brewery waste; WB = wheat bran; OC = oil cakes; CR = crop residues; ST = salt; OH = other feeds including flour mill waste.

Figure 5.1 Distribution of feeds used by urban and peri-urban dairy farms in the Harar milkshed

Almost all feedstuffs used, including roughages, are purchased except for a few farms (6 to 8%) that produce grass hay (GH), elephant grass (EG), green grass (GG) and local brewery waste (LB) in small quantities (Figure 5.1). Of the industrial by-products, brewery waste (IB) is the most commonly used feed in the urban dairy farms.

5.3.4 Major feed sources, availability and prices in urban dairy farms

The sources of some major feedstuffs and prices are shown in Table 5.3. Industrial brewery waste (IB) is one of the most commonly used feeds and it is cheaper than any other feed except local brewery waste (LB) (Table 5.3). This is an extremely important feed, as it has a high protein value, usually >20%. However, it has limitations regarding transportation and storage. This has been reported by Kenneth (1996) who indicated that the brewery grain spent or industrial brewery waste (IB) is of good quality but transportation cost normally limit hauling the wet brewery grains for more than 240 km. However, the Harar brewery factory is trying to help the smallholders by providing them with transportation at a subsidised cost when farmers buy in a group. Thus, small-scale dairy farmers of the same village usually form a small group to buy the brewery by-products from the factory.

Table 5.3 Feedstuffs, sources, estimated distances and transport cost of some feedstuffs used in the urban dairy farms of the Harar milkshed

Feedstuffs	Sources	Distance (km)	Feed price (Birr/100 kg)	Transportation (Birr /100 kg)
Brewery waste	Harar beer factory	1-2	7.7	2-3
Elephant grass	Around Harar	1-2	14	5[1]
Grass hay	Karsa	42	7 to 8	8-10
Local brewery waste	Around Harar	1-2	1.0	5
Green maize	Surrounding rural areas	1-5	35[1]	NR[3]
Green grass	Around Harar	1-5	75[1]	NR
Groundnut cake	Hamaresa factory	2-3	75	2-3
Flour mill waste	Local flour mills	1-2	NA[2]	0
Wheat bran	Dire Dawa	45	38	10-15
Groundnut hulls	Hameresa	2-3	8	2-3
Sorghum-stover	Around rural	1-5	25	-

[1] Involves human labour; NA[2] = not available; NR[3] = not relevant.

Although the current price of industrial brewery waste (IB) is fair compared to other feedstuffs, as well as its nutritional high value (containing more than 20% crude protein), farmers still expressed concern that the price of industrial brewery waste (IB) increases from time to time. In fact, according to the factory's documents that were consulted the price of industrial brewery waste (IB) increased from 1.05 in 1990 to 7.35 Birr/100 kg in 2000; an increase of more than seven-fold.

Grass hay, elephant grass (*Pennisetum purpureum)* and crop residues are the next most important feedstuffs for urban dairy production as reported by the respondents. Hay is the most widely used feedstuff next to industrial brewery waste (IB) for most part of the year. Hay normally comes from the town Karsa in the Karsa district (*warada*), which is located about 45 km from Harar. The hay from this source can be bought only by medium to large-scale farmers or those who own a truck or can afford the high transport cost. The small-scale farmers, however, depend on hay that can be produced in some limited areas within Harar city and its surrounding areas. These areas include masonries (burial places), school compounds and military academy compounds, which provide a less reliable supply, but cheaper than Karsa. Hay produced at Karsa is sold in various forms that include standing grass fields on a hectare basis before mowing the grasses. The cost of one hectare of the standing grass is estimated at 300 to 400 Birr. Sometimes retailers bale it after mowing and sell it for 12 to 13 Birr/bale of 18 to 25 kg. However, the most common practice is that dairy farmers from Harar buy it on a hectare basis and harvest it themselves, which makes the price a little cheaper compared to buying the baled hay.

Grass hay is also produced to some extent in a place called Adele within the Alemaya district, but none of the dairy farms in the Harar milkshed reported using hay from that source; probably because of the small quality of hay produced at Adele.

The scarcity of hay coupled with a greater demand than can be supplied are the main reasons for grass hay becoming so expensive in Harar. In addition, the deterioration of pastures and the competitive nature of the hay for various other purposes also inflate the prices. For example, according to the key informants in Karsa, the pasture area was estimated 10 years ago at about 80 to 100 ha. Currently, there are only 30 ha left owing to expansion of crop lands and habitational areas resulting from human population expansion in the area. Secondly, grass hay is required to cover the green *chat* leaves before it is exported, to keep it fresh, which increases the demand for hay, hence it becomes more expensive.

Crop residues, green maize and green grass are only available seasonally in small quantities. There are usually carried by children or women from the surrounding rural farms. In addition, the sorghum crop residues are also highly in demand because it is also used for domestic fuel in both rural and urban centers as well as for house construction in rural areas.

The scarcity of feed sources, mainly roughage seems to create a major bottleneck for livestock production in general and dairy production in particular in the Harar milkshed. This seems to be frustrating and may be discouraging for the dairy farmers. The situation concerning the deterioration of natural pastures at Karsa is also alarming. Perhaps the low availability and the high cost of roughage seems to be important limitations to the future expansion and to the sustainability of the urban dairy production system in the Harar milkshed. These factors limiting dairy development in the Harar milkshed should be included as important issues for more research.

5.3.5 Feed conservation methods used in urban dairy farms

Conservation of feedstuffs is one of the most important activities in dairy production systems where the feed availability is season. Hay and brewery by-products seem to receive the most attention from the urban dairy households for conservation.

5.3.5.1 Grass hay

Hay is conserved and stored in a loose form in a hay barn on almost all the urban dairy farms that were visited. Not a single farm had baled or hay stacks outside, as farmers do elsewhere in the highlands of Ethiopia. However, the hay barns take different forms, ranging from a small "chika" walled room with a roof to a large shed with a roof, but without walls. The main reason for conserving hay might emanate from the fact that hay is very expensive and the farmers are afraid of theft, rather than intending to maintain the nutritive quality of the hay.

5.3.5.2 Industrial brewery waste

Industrial brewery waste (IB), also called brewers spent grain (BSG), is a by-product of the malting industry. These are usually barley based, although there may be some maize and rice, depending on the beer manufacturing process used (Barber &

Lonsdale, 1980; Kenneth, 1996). The industrial brewery waste (IB) used in the Harar beer factory is barley based. Urban dairy households get the industrial brewery waste (IB) almost on a quota basis. Dairy households are required to register at the Harar beer factory to be entitled to purchase IB. This is available after every batch of brew produced. Dairy households are therefore required to buy it in large quantities (10 000 kg) and, therefore, have to transport, conserve and store it. Dairy households in Harar normally ensile the industrial brewery waste (IB) in silo pits in the upright position. These silos are generally of two types:

- The first type is simply a non-cement pit silo dug into the ground. The urban dairy households ensile the industrial brewery waste (IB) wet; direct without adding any water into the pit. Salt may also be added at the rate of about 2% w/w. The size of the pit varies from 1 000 kg to 3 600 kg capacity depending on the size of the dairy herd. The ensiled industrial brewery waste (IB) normally does not store well for periods exceeding 2 to 3 weeks. The pit may have a shed over it or is covered by a sheet of corrugated iron. The industrial brewery waste (IB) conserved in such a pit may dry out only on the surface and no other quality deterioration was noted.

- The second type of silo is a cement lined pit also dug into the ground. The industrial brewery waste (IB) is stored here with additional water to keep it wet all the time. The same amount of salt (2% w/w) is also added. The size of these pits is planned so that the industrial brewery waste (IB) would not last more than 2 to 3 weeks depending on the size of the herd.

These practices are in line with the storage systems and time frame suggested by Kenneth (1996). He suggested that the storage life of wet industrial brewery waste (IB) is 7 to 10 days in summer and possibly more than two weeks in winter. Furthermore, wet industrial brewery waste (IB) can be stored for longer period in a bunker silo if covered and sealed adequately, or can be stored in a bag silage system. However, in this study it was observed that without adequate cover, dairy households in Harar were able to successfully conserve the industrial brewery waste (IB) by using the above described methods. Nevertheless, this aspect may also require further evaluation.

The development of improved transport and storage systems for brewer's grain is an important research issue.

5.3.6 Chemical composition and digestibility of the most important livestock feeds used by urban dairy farms in the Harar milkshed

The chemical composition and in vitro digestibility of feeds commonly used in the urban dairy production systems of the Harar milkshed are summarised in Table 5.4. These are the results of laboratory analysis conducted at ILRI and the National Veterinary Institute (NVI).

Table 5.4 Chemical composition and in vitro digestibility of the most important livestock feeds used in the urban dairy farms within the Harar milkshed

Feeds	DM	OM	IVOMD	CP	CF	Ca	P	Ash
				%				
Groundnut oil cake (GC)	78.1	89.8	69.2	40.7	14.5	0.2	0.3	5.1
Industrial Brewery waste (IB)	18.0	89.4	50.0	22.0	21.0	0.1	0.3	4.6
Local Brewery waste (LB)	22.7	86.8	60.5	21.7	23.4	0.8	0.3	6.0
Mill waste (MW)	96.4	85.0	79.2	17.9	5.2	0.1	0.4	7.3
Green Maize (GM)	20.3	86.5	72.7	6.1	31.7	0.8	0.1	9.2
Elephant grass (EG)	15.0	82.0	63.7	15.2	38.4	0.6	0.3	13.1
Green grass (GG)	24.2	83.4	61.8	15.1	35.8	0.8	0.3	12.1
Wheat bran (WB)	94.6	87.0	56.5	12.6	11.4	0.2	0.8	6.4
Grass Hay (GH)	90.5	85.4	54.0	6.5	37.4	0.8	0.2	10.9
Groundnut hulls (GH)	93.2	89.6	12.8	10.4	66.2	0.3	0.1	3.2
Sorghum stoves (SS)	93.4	90.0	48.5	3.8	46.6	0.7	0.3	6.3

DM = dry matter; OM = organic matter; IVOMD = in vivo organic matter digestibility; CP = crude protein; CF = crude fiber; Ca = calcium; P = phoshorus; Ash = inorganic matter.

The results indicated that groundnut oil cake (*Arachis hypogaea)* had the highest crude protein (CP) followed by industry brewery waste (IB) and local brewery (LB). Lower CP was recorded for grass hay, green maize and sorghum stover respectively. The industrial brewery waste (IB) in the current study, except for its CP, had a slightly higher DM, OM and crude fiber (CF) content than reported by Kenneth (1996). He reported values of 14 to 16%, DM, 60 to 80% OM, 25 to 30% CP and 17 to 19% fiber respectively. Almost the same CP value (22%) for local brewery waste (LB) and lower value of ash were obtained compared to the previous reports (Solomon, 1984; Yosef, 1999). The highest CF was observed for groundnut hulls followed by sorghum stover, elephant grass and grass hay. The highest digestibility was observed for flour mill waste followed by green maize, elephant grass and the lowest for groundnut hulls. Most of the diets used in the peri-urban and urban dairy production systems are of fibrous nature, including sorghum stover and grass hay and these feeds have a low protein content, normally less than 7% (Kurtu, 1985; Zinash *et al.*, 1995; Solomon, 1996), which makes it difficult to promote rumen function (Whitman, 1992). Hence, non-conventional feeds, notably industry brewery waste (IB) and local brewery waste (LB) in particular are regarded as protein rich feeds that can supplement low quality feeds in urban dairy production systems of the Harar milkshed.

CHAPTER 6

MONITORING MILK PRODUCTION AND MANAGEMENT PRACTICES OF URBAN DAIRY FARMS IN THE HARAR MILKSHED

6.1 INTRODUCTION

Livestock production is rather low in Ethiopia when compared to the rest of Africa. Milk production in tropical Africa in particular is limited by the quantity and quality of feed and animal genotype. Tropical pastures mature rapidly and are generally deficient in crude protein and phosphorus and low in energy (ILCA, 1978; Ndikum-Moffor *et al.,* 1994) which are major limiting factors for milk production (Capper *et al.*, 1977; ILCA, 1978). Studies in the tropics have consistently shown that zebu breeds produce low milk yields per lactation period (which is usually also quite short), even under moderate to good feeding and management conditions. Especially zebu cows are considered poor milkers in comparison with the exotic breeds or crosses (Schaar *et al.*, 1981; Kiwuwa *et al.*, 1983; Mbah *et al.*, 1987; Kebede, 1992; Rege *et al.*, 1994; Kurtu *et al.*, 1999). Hence, the development of milk production systems in tropical conditions such as Ethiopia requires improvements, both in the genotype and in the feeding strategies.

Many countries in the tropics have attempted to replace their indigenous cattle breeds through breed substitution with exotic dairy types (Taneja & Bhat, 1986; Mbha *et al.*, 1987; Kebede, 1992; Thrope *et al.*, 1993) in order to meet the growing demand for dairy products. However, the imported dairy breeds have generally not achieved the same levels of production in the tropics as those in temperate environments. Some countries have resorted to upgrade the poor milk yielding indigenous breeds by cross-breeding with imported semen (Brannang *et al.*, 1980; Buvanendran *et al.*, 1981; Taneja & Bhat, 1986; Cunningham & Syrstad, 1987; Mbah *et al.*, 1987; Kurtu *et al.*, 1999). This strategy was aimed at improving milk production by combining the adaptive traits such as efficient utilization of poor quality roughages, tolerance to diseases and high ambient temperatures and the general hardiness of the indigenous zebu breeds with the high milk production capacity and good temperament of the exotic *Bos taurus* (Cunningham & Syrstad, 1987; Syrstad, 1990).

Urban and peri-urban dairy production systems are among the many forms of dairy production systems in the tropics and sub-tropics. These systems involve the production, processing and marketing of dairy products that are channeled to consumers in urban centers (Rey *et al.*, 1993; Staal & Shapiro, 1996). Urban and peri-urban dairy production systems have emerged to meet the increasing demand for milk in urban centers as a result of growing urbanization and increasing cost of imported dairy products. Peri-urban and urban dairy production systems contribute to the overall economic development through income and employment generation, food security, asset accumulation, poverty alleviation and improving human nutrition and health (Tegegne *et al.*, 2000).

The development and sustainability of urban and peri-urban dairy production systems require a relatively large initial capital and long-term commitment. Furthermore, the major constraints related to these dairy production systems need to be addressed. These constraints are availability and cost of genetic materials, feeding and breeding systems, animal health and veterinary services, processing and marketing of dairy produce, public health, waste handling, management and policy (Tegegne *et al.*, 2000).

In this part of the study, certain aspects of feeding and breeding practices and the productivity of the urban and peri-urban dairy production systems of the Harar milkshed were monitored and assessed over a period of one year.

6.2 MATERIALS AND METHODS

Based on the survey results, 50 dairy farms were identified in the urban and peri-urban dairy production systems of the Harar milkshed (see Chapter 2). These farms were classified into three sub-systems or clusters on the basis of major variables that include: herd size, gender of the household head, education levels and off-farm businesses (see Chapter 4). On these 50 farms there were about 900 crossbred cattle. The farms were grouped into three major dairy production sub-systems, namely: Urban Resource Poor (URP) farms in Cluster 5, Urban Medium Resource Dairy System (UMRDS) farms in Cluster 6 and Specialised Urban Dairy (SPUD) farms in Cluster 7 (Chapter 4).

From these 50 farms a total of 26 farms, representing 16 URP (Cluster 5), seven UMRDS (Cluster 6) and three SPUDS (Cluster 7) were selected on the basis of easy accessibility and short distances between the farms. Data on herd composition, number of calvings, mortalities, sales and purchases of animals, milk production performance, live weight of the cows before and after calving and body condition scores (BCS) were collected over a period of one year. (See 2.3.6 for the procedure to estimate body weight from heart girth measurements, as well as scoring body condition.)

Data collected on feeds included types of feed available, quantity offered to the animals, feed composition and nutrient content of the diets. Milking and calf rearing, housing and barn cleaning, manure production and utilization, animal health and incidence of various diseases were also monitored.

The data were also collected from farm records kept by the farmers, information obtained by interviewing the farmers and from the monitoring activities (records).

Data on herd inventory, herd composition, number of cows calving, number of deaths, sales and purchases were recorded during the monitoring phase. Performance data on milk yield, live weight of the cows before and after calving and BCS were collected and recorded as described in Chapter 2. For age at calving and calving intervals, data and information were obtained from the available records or by directly questioning the owners. Feed availability and amount offered were measured and recorded on a monthly basis as described in Chapter 2.

Estimates of the nutrient content of the available diets on each farm over different seasons, were obtained by sampling the feeds in the diet and analysing it in the laboratory. The nutrient content of the diets offered was calculated from the proportion of the individual feeds in the diet (see Chapter 2). Limiting nutrients were identified by comparing the nutrients available in the diet offered to the animals with the nutrients required as suggested by NRC (1978) (Table 6.1).

Information on milking and calf-rearing management practices were obtained from direct observations during farm visits. Housing, floor and wall types and living areas for different classes of dairy animals, as well as the cleaning frequency of the barns were obtained from direct observation and from survey results. Cost estimates of the animal housing (Birr/m^2) were determined from the information obtained from the respective farmers. Manure production per farm was measured once a month during a farm visit. Manure dry matter (DM) was estimated from a representative sample taken from several farms and oven dried at 60°C for 72 hrs.

Table 6.1 Dietary requirements of dairy cows

Nutrients	Maintenance (400 to 450 kg body mass)	Production of 6 kg milk (4% fat)	Maintenance + Production
DM (kg)	8.4	4.6	13.0
ME (MJ)	68.8	30.3	99.1
CP (g)	763.0	522.0	1285.0
P (g)	20.0	11.2	31.2
Ca (g)	29.0	16.8	45.8

Source: NRC (1978).

The reproductive performances of dairy cows were obtained from farm record books (where available), farmers were interviewed and information was gathered during the monitoring period of one year. From these data, the herd composition was calculated and compared with values that were suggested for optimum production in small-scale dairy farms (Radostits *et al.*, 1994; Hoffman, 1999) (Table 6.2).

Table 6.2 Ideal target values for the distribution of cows in the different phases of the production cycle in urban dairy production systems

	Dry and pregnant	Lactating and pregnant	Lactating and not pregnant	Dry and not pregnant
Target	17%	42%	41%	0%

Source: Radostits *et al.*, 1994; Hoffman, 1999.

The health condition and incidence of diseases were monitored on urban dairy farms. All cases of diseases, treatments, outcome and number of deaths were recorded. Observed disease types were identified based on clinical symptoms and diagnostic results obtained from the veterinary laboratory and from the local veterinarians. Annual incidences of the disease were measured by dividing the total number of animals infected by the total number of animals which were at risk. Weighted means were computed and compared between and within cluster groups for the various disease incidences using X^2 test.

6.3 RESULTS AND DISCUSSION

A selection of aspects discussed in this study is shown in Chapter 9 (Compilation of photographs).

6.3.1 Herd composition and reproductive status of cows

The results in terms of herd composition of the urban dairy farms are summarised in Table 6.3. The dairy farms selected sample for the monitoring as described in Chapter 2 had a total population of 553 crossbred dairy animals that included cows, heifers, calves and bulls. Total herd composition per Cluster 5, 6 and 7 of the urban dairy farms in the Harar milkshed is presented in Table 6.3. Calves are not disaggregated by sex.

Table 6.3 Herd composition of the urban dairy farms in the Harar milkshed

Cluster	Number of dairy farms	Cows		Heifers		Calves		Bulls		Total
		Number	%	Number	%	Number	%	Number	%	Number
5	16	99	55	27	15	51	28	3	1.6	180
6	7	155	84	18	9	44	24	7	3.8	184
7	3	112	59	39	21	40	21	1	0.5	189
Total	26	323	59	84	15	135	24	11	2.0	553

There were changes in the herd dynamics during the study period of one year and the main sources of these changes included the birth or death of calves and slaughtering of animals (Table 6.4). No animals were sold or purchased in any farm across all the groups of farms (cluster) except one heifer and one bull sold from a Cluster 5 farm. A total number of 246 calves were born from 323 cows in the three clusters. An overall calving rate average of 76% was observed for all the farms. This calving rate show that under the existing management condition, the reproductive performance of the cow herd is not too poor. Vandeplassche (1982) and Diag (1985) reported calving rates in Mozambique ranging from 69.1 to 74.8% and from 51.2 to 76.4% respectively for crossbred dairy cows on small-scale farmers. A large number of the calves that were born, died (8%) mainly because of calf scour and 37% male calves were slaughtered at a young age before weaning and fed to either dogs or wild beasts with no apparent economic benefit to the farms (Table 6.4). This was mainly because of lack of alternative ways of disposal particularly for male calves and the shortage of feeds to rear them compared to heifer claves that may turn into milk producers.

Table 6.4 Number of calves born, mortalities and slaughtered in the urban dairy farms of the Harar milkshed

Cluster	Born	Mortalities	Slaughtered male calves	Retained on the farm
5	80 (33%)	3 (3.7)	26 (30)	51 (63)
6	88 (36%)	6 (6.8)	38 (41)	44 (50)
7	78 (31%)	10 (13.0)	28 (21)	40 (51)
Total	246 (100%)	19 (8.0)	92 (37)	135 (55)

* Figures in parenthesis represent percentage.

Overall calf mortality was 8%. Farms in Cluster 7 had the highest mortalities (13%) and farms in Cluster 5 had the lowest (4%) mortalities. The observed mortality rates indicate that the smaller the herd the lower the calf losses under small-scale farm conditions. Similar trends have been reported by Hoffman (1999) in the Addis Ababa milkshed.

The distribution of the cow herds in the different production and reproductive phases in the urban dairies by cluster is presented in Table 6.5. A total of 76% cows were lactating and 24% were dry in the three clusters. Of the total number of cows, 31% was pregnant and milked, 46% was milked and non-pregnant, 10% was dry and pregnant and 14% was dry and non-pregnant respectively. It is interesting to note that the highest number of cows were non pregnant and lactating.

A large deviation of about 11% from the target value of 42% as set in Table 6.2 was found in milking and pregnant cows. An even larger deviation from the target value was observed in dry pregnant cows. In this group, the number of cows was about 10% below the target value of 17%. A higher (14%) percentage of cows were found to be dry and not pregnant, compared to the target value of zero. This means that the overall reproductive performance of the cows studied deviated negatively from the target values. However the 76% calving rate observed show that under the existing management condition, the overall reproductive performance of the cow herd is still acceptable.

Table 6.5 Distribution of the cow herds per cluster in the different phases of the productive cycle in the urban dairy farms of the Harar milkshed

Cluster	Number of dairy farms	Milking & pregnant cows	Milking & non-pregnant cows	Dry & pregnant cows	Dry & non-pregnant cows	Total
5	16	33 (33%)	47 (47%)	14 (14%)	5 (5%)	99
6	7	34 (30%)	54 (47%)	11 (10%)	16 (14%)	115
7	3	32 (29%)	46 (42%)	6 (6%)	25 (23%)	109
Total	26	99 (31%)	147 (46%)	31 (10%)	46 (14%)	323

The distribution of cows over the different phases of the productive cycle showed clearly that too many cows were not milking and not pregnant and a small percentage of cows were pregnant and lactating when compared to the target values of 0 and 42%. The percentage of cows that were dry and not pregnant (14%) suggest reproductive management problems in the farms studied. These dry and non-pregnant cows will have to be culled from the farms for economic reasons. A large percentage of dry and non-pregnant cows were recorded in large and specialized farms, compared to the smaller urban dairy farms in Cluster 5. Hoffman (1999) has reported similar findings in peri-urban and urban dairy areas around Addis Ababa. She reported values of 18% for pregnant and dry, 21% for milking and pregnant, 21% for milking and not pregnant and 9% for dry and non-pregnant cows respectively. Compared to the current study, Hoffman (1999) found a lower number of dry and non-pregnant cows. This might be owing to the improved feeding conditions and better reproductive management provided for dairy cows around Addis Ababa compared to those in the Harar milkshed.

6.3.2 Monthly calving distribution

The monthly calving distribution of the urban dairy farms is shown in Table 6.6. A total of 246 calvings were recorded during the study period of one year.

The highest calving rate was recorded in March (17%), followed by September (12%). The lowest number of calvings occurred in November (1%) and December (4%). The highest number of calvings was recorded during March to May which falls during the short rains (39%) and the lowest number of calvings was during October to December which falls in the later part of the dry season (11%). Almost similar patterns of calving were observed in the three clusters (Table 6.6).

Table 6.6 Calving distribution per month and per cluster in the urban dairy farms of the Harar milkshed

Month	Cluster 5	Cluster 6	Cluster 7	Total	%
Jan	5	8	6	19	8
Feb	5	7	2	14	6
Mar	14	15	12	41	17
Apr	12	5	9	26	11
May	9	13	6	28	11
Jun	10	8	4	22	9
Jul	7	7	6	20	8
Aug	4	11	4	19	7
Sep	7	10	13	30	12
Oct	6	1	8	15	6
Nov	0	0	3	3	1
Dec	1	3	5	9	4
Total	80	88	78	246	100

These results agree well with those of Kiwuwa *et al.* (1983) and Kurtu *et al.* (1999), who reported an almost similar pattern of calving distribution, but with slightly higher values for the main rainy season followed by the short rainy season. These authors found that there were calving percentages of 56%, 43% and 41% in June to September, March to May and October to February, respectively. The difference between their findings and the present results could probably have been as a result of the feeding and management systems because those reports were under open-grazing conditions which are more affected by the effects of the season. In addition, their data were obtained under research station conditions where the environments are better controlled.

The seasonal calving distribution observed in this study can partially be explained by the season's effect because the majority of the cows conceived during the main rainy season (June to September) and calved during the short rainy season (March to May). During this main rainy period, feedstuffs like green and succulent plant materials, including green grasses, green maize and weeds provide the cows with more protein and especially β-carotene, the precursor of vitamin A, mostly associated with cow fertility causing the cows to come in heat (Slater, 1991). On the other hand this pattern of calving tends to provide an irregular distribution of calving through the year and subsequently irregular supplies of milk. Milk production is highly dependent on the availability and quality of feedstuffs which are normally influenced by the season.

In addition, there were little attempts to meet the feed requirement of the cows over different lactation stages. Nutrient and energy requirements of a cow differ considerably at different stages of lactation, calling for appropriate feeding strategies (Slater, 1991). Apparently no appropriate feeding strategies seem to have been applied to meet the different cows' requirements over the production cycle. The urban dairy farms in the Harar milkshed seem to follow a calving distribution throughout the year, coupled with traditional feeding and management as well as milk production patterns. This would hardly enable the farms to ensure a continuous milk production and supply on a regular basis over different seasons of the year in order to meet the market demand and subsequently meet the desired profit expected by the producer on a sustainable and regular basis.

6.3.3 Milk production

A total of 246 cows gave a total milk yield of 84 312 liter during the study period of one year. The seasonal distribution of milk production in the urban dairy farms of the Harar milkshed is presented in Table 6.7.

The highest milk yield was obtained during the rainy seasons and the lowest during the dry season. More than 28 000 liter (34%) of milk was produced during the long rainy season (June to September) and only about 12 000 liter (14%) of milk was produced during the dry season. This difference was significant (P<0.05) and may be explained by the irregular annual calving distribution, which is partly associated with the unbalanced feed conditions over the seasons. During the wet seasons the bulky feeds especially green plants including weeds, are available to the animals while during the dry season these feedstuffs were in most cases not available (Slater, 1991). In addition, the available literature indicates that tropical pastures tend to mature rapidly and are generally deficient in crude protein, phosphorus and energy during dry season of the year (Capper *et al.*, 1977; ILCA, 1978; Ndikum-Moffor *et al.*, 1994).

Table 6.7 Seasonal distribution of milk production in the urban dairy farms of the Harar milkshed

Months	Season	Milk yield (liter)	Percentage
October to December	Beginning of dry season	16 171[a]	19
January to February	End of dry season	11 879[b]	14
March to May	Short rains season	28 014[c]	33
June to September	Long rains season	28 248[c]	34
Total		84 312	100

a,b,c Means with different superscripts within columns differ significantly (P<0.05).

The mean milk yield/cow/day seems to vary little over the 12 months of the year. However, during the rainy seasons, the total milk produced tends to be higher. The highest total milk yield occurred during March and April, followed by July and September, while the lowest occurred during December and February. This was strongly influenced by the number of cows that calved (Table 6.6). The differences for the remaining months was not clearly discernable (Table 6.8). The same type of result was reported for crossbred cattle in Ethiopia (Kiwuwa *et al.*, 1983; Kurtu *et al.*, 1999). Apparently, the difference in milk production seems to be more differentiated between clusters than between months (Table 6.9).

Differences in milk production between clusters tend to reflect the discrepancy in management practices, particularly feeding of the herds in the three clusters (Table 6.9). Average milk yield per cow per day was almost the same in all three clusters. The total milk yield between the three clusters (Table 6.9) was significantly different

(P<0.05). Farms in Cluster 6 produced 29 508 liter per month, the highest yield, followed by Cluster 5 with 28 611 liter and Cluster 7 with 26 193 liter (Table 6.9). Differences in milk yield between the clusters could probably be explained by differences in the herd size, number of cows calving during the study period, feeds available and the commitment of the owners. The smaller the herd (Cluster 5) the easier the management, but shortages in feeds results in lower milk production. The larger the herd size (Cluster 7) the more feeds and more commitment are required. However, the commitment for improved production seems to be lacking in this group as they are also engaged in other businesses. Tegegne *et al.* (2000) indicated that as the dairy herd size increases, more feeds, better management and long-term commitment are required to get increased production.

Table 6.8 Average number of calves born, daily milk yield per cow and total milk yield of urban dairy farms in the Harar milkshed

Month	Number of calves born	Average milk yield/cow/day (liter)	Total milk yield per month (liter)
Jan	14 ± 3.9	6.72 ± 0.14	6398
Feb	19 ± 3.2	5.37 ± 0.41	5481
Mar	41 ± 3.9	5.98 ± 0.45	10897
Apr	26 ± 3.5	6.81 ± 0.95	8800
May	28 ± 4.3	5.85 ± 0.54	8317
Jun	22 ± 4.2	5.32 ± 0.34	6686
Jul	20 ± 3.6	5.64 ± 0.45	6862
Aug	19 ± 3.9	5.34 ± 0.28	6337
Sep	30 ± 3.7	5.53 ± 0.14	8363
Oct	15 ± 3.7	5.74 ± 0.96	6046
Nov	3 ± 2.6	5.21 ± 0.71	5172
Dec	9 ± 3.9	5.62 ± 0.79	4953
Total	246		84312

In conclusion, the irregular calving distribution over the year, irregular milk production and a lack of strategic feeding systems were important management problems identified in the urban dairy production systems. It was also noted that these problems were more pronounced in Cluster 7 compared to Clusters 5 and 6 and require intervention to improve dairy productivity in the Harar milkshed.

Table 6.9 Average daily milk yield per cow and total milk production per cluster of the urban dairy farms in the Harar milkshed

Cluster	Milk/cow/day (liter)	Total milk (liter)
5	5.71 ± 1.31	28611[a]
6	5.89 ± 1.21	29508[a]
7	5.62 ± 1.32	26193[b]

a, b Means with different superscripts within columns differ significantly (P<0.05).

6.3.4 Reproduction performance

Available data only allowed the analysis of age at first calving, lactation length, number of services per conception and calving intervals. The rest of the reproductive traits could not be addressed owing to a lack of data mainly as a result of the study period being only one year. Data on some production indices for the urban dairy farms such as age at first calving, lactation length, number of services per conceptions and calving interval are presented in Tables 6.10 and Table 6.11.

Table 6.10 Average age at first calving, calving interval and lactation length per cluster of the urban dairy farms in the Harar milkshed

Cluster	Age at 1st calving (months)	Calving interval (months)	Lactation length (months)
5	30.97 [a]	16.8 [a]	310 [a]
6	29.72 [a]	15.5 [a]	322 [a]
7	32.50 [c]	17.5 [b]	332 [a]
Over all	30.06	16.6	321

a, b, c Means with different superscripts within columns differ significantly (P<0.05).

The overall mean age at first calving was 30.6 months, but differences between clusters were observed. Cows in Clusters 5 and 6 calved for the first time two months earlier than cows in Cluster 7. The overall age at first calving is 6 months later than the target age of 24 months and requires attention because it is greater than the 28 months suggested by Radostits *et al.* (1994). However, these crossbred cows had their first calves much earlier compared to local pure breds, which normally do not give birth to their first calves before 4 years of age (Swenson *et al.*, 1981; Albero, 1983). This is supported by several reports on crossbred cattle in Ethiopia that have shown better reproductive performances than the indigenous cattle (Swenson *et al.*, 1981; Albero, 1983; Kiwuwa *et al.*, 1983). Differences among the clusters for age at first calving, however, could be attributed to the different levels of management provided to the crossbred cow. As indicated by Preston (1989) the relative advantages of crossbred cows depend on the level of management and adequate nutrition provided.

Table 6.11 Mean number of services per conception by cluster of the urban dairy farms in the Harar milkshed

Cluster	Number of cows	Number of services/ Conception
5	88	2.9 ± 1.4^{b}
6	74	2.5 ± 1.3^{a}
7	81	3.1 ± 1.3^{b}
Overall	82	2.8 ± 1.3

a, b Means with different superscripts within columns differ significantly ($P<0.01$).

The calving intervals for the cows in the different clusters are also shown in Table 6.10. The overall mean calving interval observed in this study was very long (498 days) whereas the optimum is around 365 to 400 days as suggested by Kiwuwa *et al.* (1983), Matthewman *et al.* (1993) and Perera (1999). The calving interval observed, however, is in agreement with Bekele *et al.* (1991) who reported 15.8 months in Ethiopia which is longer than the 13.2 months reported by Kiwuwa (1967) in Uganda. Significant ($P<0.05$) shorter mean calving intervals were noted for cows in Clusters 5 and 6 compared to those in Cluster 7.

Longer calving intervals are generally reflections of the problems associated with poor nutrition, health and reproductive managements (Kiwuwa *et al.*, 1983; Matthewman *et al.*, 1993; Perera, 1999). The calving interval needs to be shortened for improved reproductive and productive performances (Kiwuwa *et al.*, 1983; Matthewman *et al.*, 1993; Perera, 1999). Thus, the results of the present study regarding calving interval calls for appropriate interventions, based on the specific cause or causes for the long calving intervals. Therefore there is a definite need to identify the specific underlying causes for the long calving intervals.

The mean number of services per conception by cluster are presented in Table 6.11. The overall mean number of services per conception is 2.8±1.34, which is higher than that reported by several authors: in Ethiopia Bekele *et al.* (1991) reported 1.83 ± 0.90 and in Tanzania Munjuni *et al.* (1990) 1.75 ± 0.39 service/conception. However, Tegegne (1997) in Ethiopia reported 2.6 services per conception, which is in agreement with the results of this study.

Cows in Cluster 6 required a smaller number of services ($P<0.01$) compared to those cows in Cluster 5 and especially Cluster 7. Cows in Cluster 7 had slightly more services/conception than cows in Cluster 5, but the difference was not significant ($P>0.05$). Higher numbers of services mean longer calving intervals, because the cows in Cluster 7 had longer calving intervals compared to cows in Clusters 5 and 6 (Table 6.10). However, cows in all clusters required more services than the target of 1.5 services recommended by Radostits *et al.* (1994). It is important to note that all the target values used are based on the North American and European dairy production systems, because there are no established standards either for Ethiopia or for tropical Africa as such. Larger numbers of services per conception are the result of a number of factors including poor management, feeding, heat detection, time of services, semen quality and skills of the inseminator (Branning & Person, 1990) and requires attention.

It can be concluded that the overall reproductive performance of the cows in this study deviated negatively from the target values and these deviations were larger in Cluster 7 compared to Clusters 5 and 6. Therefore, reproductive problems were also important factors that reduce the productivity of urban dairy farms and need to be addressed to improve productivity in the urban sub-system of the Harar milkshed.

6.3.4.1 Pre-partum and post-partum body weight changes

The mean body weight of dairy cows before and after parturition in the urban dairy production systems of the Harar milkshed is presented in Table 6.12.

The average body weight of the cows in all clusters was 446 and 419 kg before and after calving respectively. Cows in Cluster 6 were the heaviest and cows in Cluster 7 were the lightest before calving. Cows in Cluster 7 were significantly ($P<0.05$) lighter than those in Clusters 6 and 5 after calving. For Clusters 5 and 6 this difference was not significant ($P>0.05$). The weight differences before and after calving for Clusters 5 and 7 was almost the same (6%) whereas this weight difference for cows in Cluster 6 was a bit higher (7%). These small differences in the body weights noted for cows in Clusters 5 and 6 before and after calving compared to the cows in Cluster 7 could be attributed to the better feeding levels provided to the cows, especially before calving.

Table 6.12 Pre-partum and post-partum body weights (mean ±sd) of cows on urban dairy farms in the Harar milkshed

Cluster	Number of cows	Pre-partum weight	Post-partum weight
5	80	454.1 ± 11.6^{b}	427.3 ± 14.6^{b}
6	88	474.6 ± 13.6^{c}	448.6 ± 13.8^{b}
7	78	411.3 ± 14.5^{a}	382.3 ± 11.2^{a}
Overall	82	466.6 ± 13.2	419.4 ± 13.2

a, b Means with different superscripts within columns differ significantly ($P<0.05$).

The means and standard deviation for body condition scores (BCS) of the cows before and after calving in the urban dairies of the Harar milkshed.

Table 6.13 Body condition scores of pre-partum and post-partum cows (mean ±sd) in urban dairies in the Harar milkshed

		Body condition score	
Cluster	Number of cows	Pre-partum	Post-partum
5	80	3.1 ± 0.9^{b}	3.0 ± 0.3^{b}
6	88	3.3 ± 0.0^{a}	3.2 ± 0.0^{a}
7	78	2.9 ± 0.1^{b}	2.8 ± 0.7^{b}
Overall	82	3.15 ± 0.5	3.0 ± 0.3

a, b Means with different superscripts within columns differ significantly ($P<0.05$).

The overall mean BCS's of the cows were 3.15 and 2.71 before and after calving respectively. This means that cows in all clusters were not in good conditions after calving with body scores below 3 BCS, which has been described as poor by Wildman *et al.* (1982). This might be the result of underfeeding particularly resulting from a lack of adequate feed supplies. There were differences among the dairy farms in the different clusters. The mean body condition scores of the cows in Cluster 6 were better before and after calving owing to a small difference in BCS observed after calving compared to cows in Clusters 5 and 7. The BCS of cows in Cluster 6 were the highest and cows in Cluster 7 had the lowest score before calving ($P<0.05$). Differences in BCS before calving between cows in Clusters 5 and 7 were not significant ($P>0.05$). After calving however, cows in Cluster 6 showed higher BCS than cows in Clusters 5 and 7 and these differences were significant ($P<0.05$). There was no difference in BCS for cows in Clusters 5 and 6 after calving. Except for Cluster 6, the average BCS before and after calving was lower than the acceptable level of BCS suggested by Wildman *et al.* (1982) for optimum production. BCS changes before and after calving in the present study indicate that cows, particularly in Clusters 5 and 7, were in sub-optimal condition probably because of a lack of proper feeding before calving. This would subsequently result in lower milk production. Poor BCS at or after calving (<3) often results in lower peak milk yield and lower total milk lactation yield (Wildman *et al.*, 1982). Cows with a higher BCS (Cluster 6) produced more milk (13%) than the cows with a lower BCS in Cluster 7 (Table 6.9). Cows with a high BCS (Cluster 7) also had the highest body mass (Table 6.12).

Dairy cows should not lose more than one point in BCS soon after calving because excessive loss of body condition in early lactation has been shown to reduce the reproductive efficiency (Wildman *et al.*, 1982). The low body weights and body condition scores of cows before and after calving in this study appears to have resulted from the feeding systems employed (see later in Table 6.15).

In conclusion, lower body weight and poor body condition scores of the cows before and after calving were found to be important factors in management of urban dairy, influencing productivity of the dairy herds in the milkshed. These problems were noted to be more apparent in the dairy herds in Cluster 7 than in Clusters 5 and 6.

6.3.5 Feed resources in the urban areas

6.3.5.1 Feed resource availability and utilization in the urban areas

The inventory of feeds which was recorded over 12 months indicates that small-scale dairy farms in the urban areas of the Harar milkshed used different types of feeds in the diets of their dairy cows (Figure 6.4).

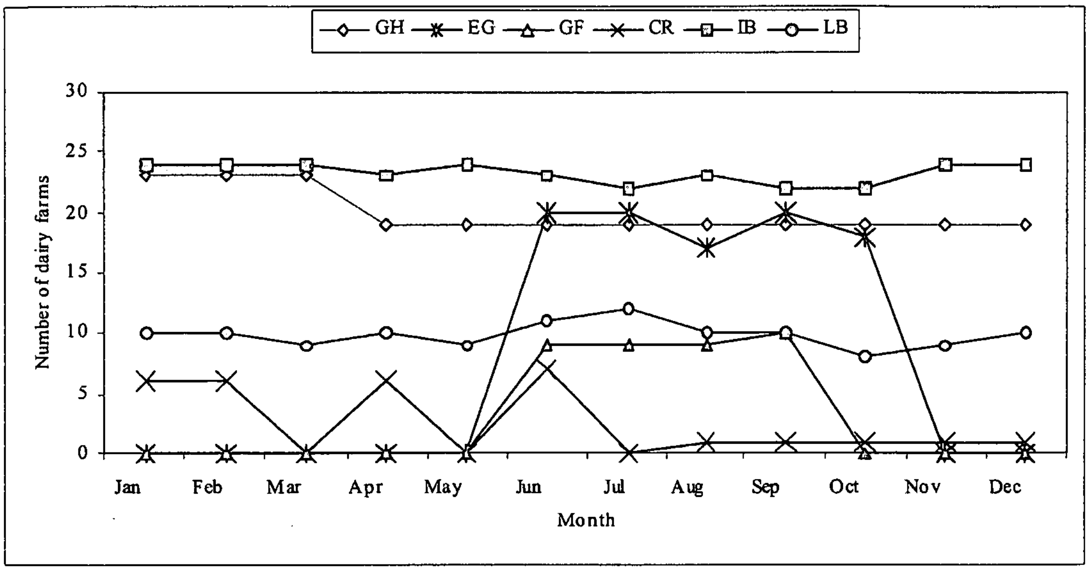


Figure 6.4 **Feed types available in the diets of dairy cows during different months in the urban dairy farms of the Harar milkshed (GH=grass hay; EG=elephant grass; GF=green feeds (green maize, green grass and weeds); CR=crop residue; IB=industry brewery wastes; LB=local brewery waste).**

Grass hay (GH) was available in 73% of the farms from April to December and 88% of the farms from January to March. Elephant grass (EG) and green feeds (GF) were only from June to September (wet season) available in 73% and 35 % of the total dairy farms, respectively. The green feeds (GF) in this study includes green maize, green grasses and weeds. Industrial brewery wastes (IB) were available nearly in all of the farms (84 to 92%) almost throughout the year. Local brewery waste (LB) and crop residues (CR) included in the dairy diets of a very limited number of farms, 38% and 10% on average respectively. Crop residues (CR) was available sporadically and mostly during the later part of the dry period (January to February), whereas local brewery waste (LB) was available almost on a regular basis over the year. However, the distribution of the availability of feed types in a diet tends to vary in the dairy farms in different clusters.

The type of feedstuffs used by dairy farms in the different clusters over different seasons are presented in Figures 6.5, 6.6 and 6.7. In dairy farms in Cluster 5, the proportion of dairy farms feeding industry brewery waste (IB), grass hay (GH) and local brewery waste (LB) were 78%, 75% and 30% respectively. These feed types were available all year round. In all three clusters the proportion of farms feeding green feeds (GF) and elephant grass (EG) were 31% and 63% respectively. These feed types were available only during the wet season.

Except for minor differences, dairy farms in Clusters 5 and 6 used similar types of feeds in the diets for their animals (Figures 6.5 and 6.6). The main difference being that in Cluster 5 there were a few (6%) farms using wheat bran (WB) in the diets, but 43% of the dairy farms in Cluster 6 used wheat bran (WB). In addition, a higher proportion (71%) of the farms in Cluster 6 used local brewery waste (LB) compared to 12% of the farms in Cluster 5.

Farms in Cluster 7, however, differed from the farms in Clusters 5 and 6 in the types of feeds they were using. Oil cakes (OC) (33%) were used by farms in Cluster 7, while in Clusters 5 and 6 oil cakes (OC) were not used and no local brewery wastes (LB) were used in the Cluster 7 (Figure 6.7).

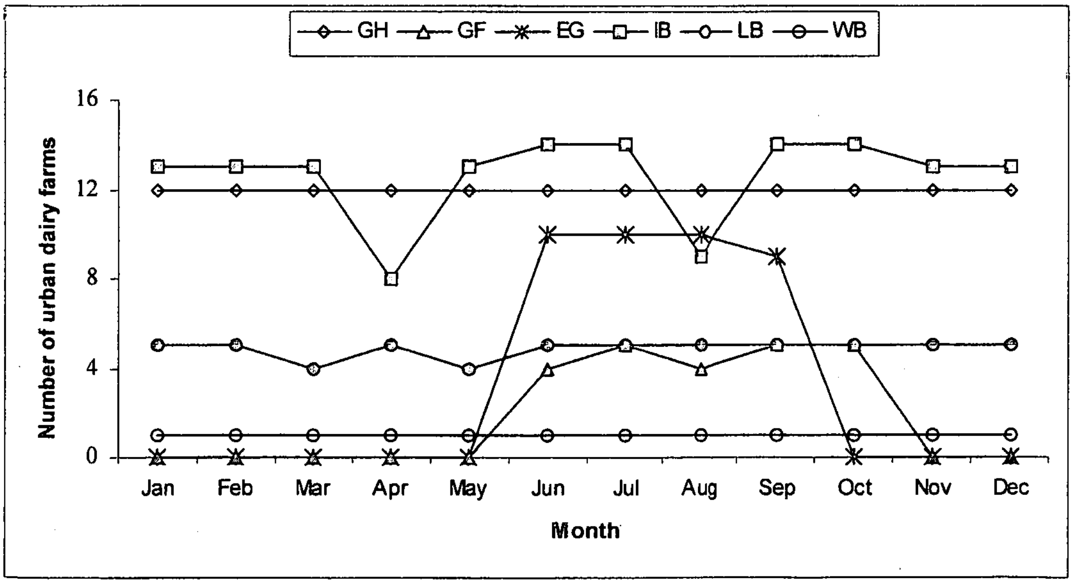


Figure 6.5 **Feed types available in the diets of dairy cows during different months in Cluster 5 of the urban dairy farms of the Harar milkshed (GH=grass hay; EG=elephant grass; GF=green feeds (green maize, green grasses and weeds); CR=crop residue; IB=industry brewery waste; LB=local brewery waste; WB=wheat bran).**

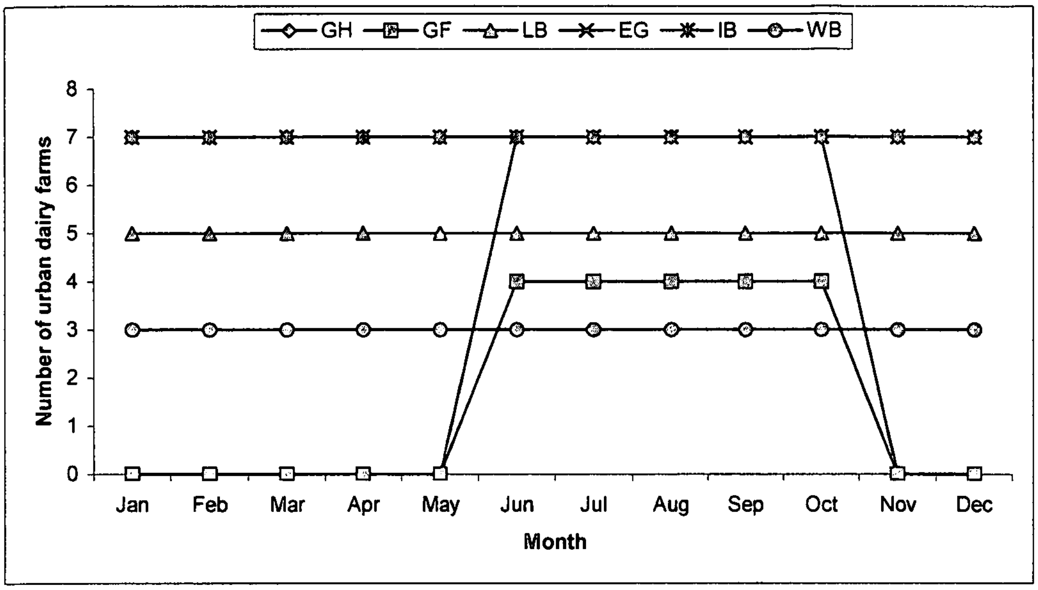


Figure 6.6 **Feed types available in the diets of dairy cows during different months in Cluster 6 of the urban dairy farms of the Harar milkshed** (GH=grass hay; EG=elephant grass; GF=green feeds (green maize, green grasses and weeds); CR=crop residue; IB=industry brewery waste; LB=local brewery waste; WB= wheat bran).

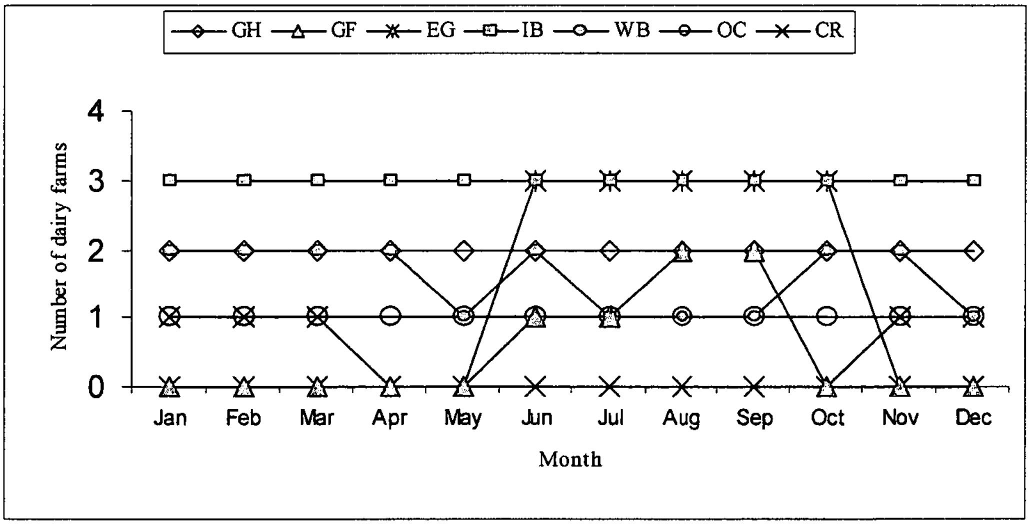


Figure 6.7 **Feed types available in the diets of dairy cows during different months in Cluster 7 of the urban dairy farms of the Harar milkshed** (GH=grass hay; EG=elephant grass; GF=green feeds (green maize, green grasses and weeds); CR=crop residue; IB=industry brewery waste; LB=local brewery waste; OC=oil cakes; WB=wheat bran).

The fact that farms in Cluster 7 are able to feed oil cakes (OC) and wheat bran (WB), which are relatively expensive feedstuffs, but no local brewery waste (LB) which are relatively cheaper, seems to reflect the differences in the resources and capital available between the farms in the different clusters.

6.3.5.2 Nutrient content of feeds and the proportion of individual feeds included in the dairy rations

The average quantities (both as fed and on a dry matter basis) of the feeds offered and the nutrient content of the ration fed to the dairy cows in the urban dairies of the Harar milkshed are shown in Table 6.14.

In the three clusters 9.25 kg DM of feed was offered on average to each milking cow per day (Table 6.14). The highest (37%) contribution of any feed in the ration was from industry brewery waste (IB) and the lowest (1.9%) was from sorghum stover (SS). Industry brewery waste (IB) and grass hay (GH) were consistently available in almost all the farms throughout the year, whereas the other feeds varied depending on the season and the clusters (See Figures 6.4, 6.5, 6.6 and 6.7).

Table 6.14 Average daily feed intake per cow and nutrient content of feed resources used on the urban dairy farms of the Harar milkshed

Feed type	Amount* fed (kg)	Dry matter (DM) (kg)	Crude protein (CP) (g)	Metabolizable energy (ME) (MJ)	Phosphorus (P) (g)	Calcium (Ca) (g)
Grass hay	1.7	1.5	98.2	10.5	3.5	11.5
Green maize	0.8	0.2	9.6	1.0	0.2	1.2
Green grass	1.3	0.3	46.4	2·9	1.0	2.3
Elephant grass	4.4	0.7	131.6	6.4	1.7	4.6
Industry brewery waste	19.0	3.4	671.4	22.3	11.7	3.1
Local brewery waste	2.7	0.6	114.8	5.3	1.7	5.0
Wheat bran	1.5	1.4	171.4	10.3	10.5	2.2
Oil cakes	0.3	0.3	105.7	2.	0.8	0.4
Groundnut hulls	0.2	0.2	20.8	0.1	0.1	0.6
Mill waste	0.2	0.2	33.3	2.1	0.7	0.3
Sorghum stover	0.6	0.6	6.8	3.5	1.8	3.6
Total	32·6	9.3	1410.0	66.5	33.6	34.6

* There were hardly any of the feeds left over, therefore feed allowance is the same as feed intake.

On average the dairy ration contain 1410 g CP, 67 MJ ME, 33.6 g P and 34.6 g Ca. According to the recommendation by NCR (1978) a dairy cow weighing 450 kg and producing 6 kg milk per day would require about 13 kg DM, 100 MJ ME, 1285 g CP, 31 g P and 46 g Ca (Table 6.1). Based on this recommendation, the dairy ration was particularly deficient in energy (by 37% of the requirement). About 5 kg (64%) less

DM was provided than the requirement. Calcium was 10 g (22%) less than the requirement.

The contribution that each individual feedstuff makes to the dairy ration becomes more apparent in the different months and in different clusters than what is evident in the overall mean of the three clusters (See Figures 6.5, 6.6 and 6.7). Some important feedstuffs were not available on some farms, for example, oil cakes (OC) have not been used at all in Cluster 5 farms and wheat bran (WB) was also not used by many farms. Therefore, the average for the three clusters does not adequately reflect the feeding status of dairy cows as such and the examining of detailed aspects of clusters might provide a better picture of the feeding status of the dairy cows.

The nutrient content of the dairy rations used in the dairy farms in the three clusters is shown in Table 6.15. The differences between clusters 5 and 6 were not significant (P>0.05) except for Ca content while the ration of Cluster 7 was significant (P<0.05) poorer in all nutrients.

Table 6.15 Average daily feed allowance and the nutritional content of dairy rations used in the different urban clusters of the Harar milkshed

Cluster	Amount* fed (kg)	Dry matter (DM) (kg)	Crude protein (CP) (g)	Metabolizable energy (ME) (MJ)	Phosphorus (P) (g)	Calcium (Ca) (g)
5	35.8[a]	9.4[a]	1465.5[a]	71.4[a]	35·8[a]	40.8[a]
6	36.3[a]	9.4[a]	1518.6[a]	68.2[a]	33.8[a]	36.8[b]
7	25.6[b]	8.9[b]	1245.5[b]	59.7[b]	31.2[b]	26.1[c]
Overall means	32.6	9.3	1409.8	66.5	33.6	34.6

* There were hardly any of the feeds left over, therefore feed allowance is the same as feed intake.
a, b, c Means with different superscripts in the same column differ significantly (P<0.05).

At this point it is important to look at a complete breakdown of the typical diets and rations used by the farms in the three clusters. The ration composition and nutrient content of the dairy farms in the three clusters are shown in Tables 6.16, 6.17 and 6.18. Dairy cows in Cluster 5 received a ration containing about 33% and 29% less DM and energy respectively than required for the optimum production based on cow weight and the current levels of milk production (6 kg) (NCR, 1978).

Table 6.16 Average daily feed allowance and the nutritional content of dairy rations used in urban Cluster 5 of the Harar milkshed

Feed type	Amount* fed (kg)	Dry matter (DM) (kg)	Crude protein (CP) (g)	Metabolizable energy (ME) (MJ)	Phosphorus (P) (g)	Calcium (Ca) (g)
Grass hay	1.9	1.8	113.1	11.4	6.0	13.3
Green maize	1.3	0.3	16.0	2.2	0.3	2.0
Green grass	2.0	0.5	74.1	05.1	1.7	3.5
Elephant grass	4.6	0.7	103.2	8.2	1.6	5.2
Industry brewery waste	20.0	3.6	546.5	23.4	12.2	3.2
Local brewery waste	4.4	1.0	217.0	8.3	2.9	8.3
Wheat bran	0.9	0.8	104.6	6.3	6.4	1.3
Oil cakes	0.0	0.0	0.0	0.0	0.0	0.0
Groundnut hulls	0.0	0.0	0.0	0.0	0.0	0.0
Mill waste	0.3	0.3	50.0	3.2	1.0	0.4
Sorghum stover	0.6	0.6	21.0	3.4	1.8	3.6
Total	35.8	9.4	1245.3	71.4	33.8	40.8

* There were hardly any of the feeds left over, therefore feed allowance is the same as feed intake.

Almost a similar trend was observed in the dairy farms in Cluster 6 (Table 6.17).

Cows in the farms of Cluster 6 seem to have been better fed compared to those in Clusters 5 and 7. The farms in Cluster 6 differ in that the ration contains about 32% more energy and 18% more CP compared to the farms in Cluster 7. However, the cows in Cluster 6 were fed inadequate levels of energy by about 33% less than the requirements (Table 6.17).

Generally, dairy farms in all clusters were fed inadequate levels of nutrients as well as in DM and energy. This could be because the wheat bran (WB) and industry brewery waste (IB), which are rich in energy, were not adequately included in the rations. Inclusion of wheat bran (WB) was restricted probably because of the high cost involved, especially for farms in Clusters 5 and 6. The industry brewery waste (IB) was limited to about 22 kg/cow/day, while technically it is possible to include relatively large qualities of 40-80 kg/cow/day in dairy rations without adverse effects on health, provided the animals are introduced to increasing levels of the feed gradually and the industry brewery waste (IB) is free of molds (Barber & Lonsdale, 1980). However, dairy producers have expressed concern that they very often hear complaints from their clients that the milk quality deteriorates in terms of taste and flavour and has a lower fat content when cows are fed a large amount of industry brewery waste (IB) and elephant grass (EG). The information gained during this study could not shed any light on the reasons for these observations and complaints by the farmers. Thus, further investigation of industry brewery waste (IB) is required to determine the optimum inclusion levels that would meet the specific production objectives of the urban dairy farms in the Harar milkshed, without affecting the milk negatively.

Table 6.17 Average daily feed allowance and the nutritional content of dairy rations used in urban Cluster 6 of the Harar milkshed

Feed type	Amount * fed (kg)	Dry matter (DM) (kg)	Crude protein (CP) (g)	Metabolizable energy (ME) (MJ)	Phosphorus (P) (g)	Calcium (Ca) (g)
Grass hay	1.9	1.7	111.1	12.3	2.8	13.0
Green maize	0.5	0.1	6.7	1.1	0.1	0.8
Green grass	1.8	0.4	65.0	12.3	1.5	3.3
Elephant grass	4.2	0.6	94.1	5.7	1.6	3.9
Industry brewery waste	22.6	4.1	894.2	26.5	13.8	3.7
Local brewery waste	3.5	0.8	172.1	7.5	2.3	6.6
Wheat bran	0.9	0.8	104.6	6.3	6.4	1.3
Oil cakes	0.0	0.0	0.0	0.0	0.0	0.0
Groundnut hulls	0.0	0.0	0.0	0.0	0.0	0.0
Mill waste	0.3	0.3	50.0	3.1	1.0	0.4
Sorghum stover	0.6	0.6	21.0	3.4	1.8	3.8
Total	36.3	9.4	1518.8	68.5	31.2	36.8

* There were hardly any of the feeds left over, therefore feed allowance is the same as feed intake.

Mineral supplementation, particularly calcium, was also inadequate in all clusters, an aspect which requires consideration in the future.

Since these urban dairy farms depend to a large extent on industry brewery waste (IB) and local brewery waste (LB) to feed dairy cows and these feeds are readily available almost throughout the year, it seems that there would be a lesser effect from seasonal influences on nutrient supply in the ration as such, especially if a strategic ration formulation is practiced. This calls for corrections in the ration composition through periodic adjustments of the amount and quality of the cows' rations based on the level of milk production and the physiological development stage of the cows. Hence, a lack of strategic feeding is usually referred to as uneconomical and leads to a loss of profit (Slater, 1991). This type of feeding system could be uneconomical simply because cows are getting less nutrients and energy than their requirements, resulting in a lower milk production and subsequently realising less returns to the dairy farm. The same ration was fed to heifers, growing calves and bulls, but in lower quantities. Industry brewery waste (IB) is usually fed for the heifers at a level of about 50% for that of the cows and the bulls are fed some of it when there is an excess amount of the feed. All the feedstuffs are given to animals in their respective barns.

Table 6.18 Average daily feed allowance and the nutritional content of dairy rations used in urban Cluster 7 of the Harar milkshed

Feed type	Amount* fed (kg)	Dry matter (DM) (kg)	Crude protein (CP) (g)	Metabolizable energy (ME) (MJ)	Phosphorus (P) (g)	Calcium (Ca) (g)
Grass hay	1.2	1.1	70.4	7.8	1.7	8.3
Green maize	0.5	0.1	6.1	0.8		0.8
Green grass	0.0	0.0	0.0	0.0	0.0	0.0
Elephant grass	4.9	0.7	110.1	5.2	1.9	4.6
Industry brewery waste	14.5	2.6	573.4	16.9	8.9	2.4
Local brewery waste	0.0	0.0	0.0	0.0	0.0	0.0
Wheat bran	3.7	3.5	305.0	18.4	18.6	3.9
Oil cakes	2.0	1.6	317.1	6.6	2.5	1.3
Groundnut hulls	0.7	0.6	62.5	0.4	0.3	1.7
Mill waste	0.0	0.0	0.0	0.0	0.0	0.0
Sorghum stover	0.6	0.6	21.0	3.4	1.7	3.8
Total	25.8	8.9	1465.5	59.7	35.8	26.7

* There were hardly any of the feeds left over, therefore feed allowance is the same as feed intake.

In general the dairy rations were deficient in both quantity and quality and could not meet the nutritional requirements of the dairy herd. The ration was particularly deficient in energy and calcium. These deficiencies were much larger in the farms from Cluster 7 than in those of Clusters 5 and 6. Thus, feeding and nutritional problems were clearly identified as one of the most important limitation for dairy production. These aspects will have to be looked into in future dairy improvement strategies for the Harar milkshed.

6.3.6 Calf rearing management

6.3.6.1 Feeding methods

The number and proportion of urban dairy farms using different calf rearing methods are shown in Table 6.19.

The majority of the urban dairy farms studied used bucket feeding for calf rearing. On the remaining farms natural suckling was used for calf rearing as well as before milking to stimulate the letdown before actual milking started. Those farms that allow the calves to suckle after milking did not use suckling for the initiation of milk letdown. No farms observed used washing of udders for milk letdown, including those using bucket feeding, but almost all provided a milk ration during milking to the cows.

Table 6.19 The number and proportion of urban dairy farmers following different calf feeding methods in the Harar milkshed

Rearing method	Calf rearing	
	Number of farms	%
Suckling before milking	4	15
Suckling after milking	1	4
Suckling before and after milking	6	23
Bucket feeding	15	58
Total	26	100

All farms in Cluster 7 (Table 6.20) used bucket feeding while only about 50% of the farms in Clusters 5 and 6 used this feeding method.

The farms using bucket feeding or those farms allowing the calves to suckle after milking are likely to get a reduced milk yield and lower calf performance (Preston & Leng, 1987; Matthewman *et al.*, 1993; Tesfaye & Gebre-Egziabher, 1995; Das *et al.,* 1999) and reduced milk quality (Boden & Leaver, 1994). Particularly if no other means of milk letdown initiation is used other than suckling, would lead to a much lower milk yield (Matthewman *et al.*, 1993), because the milk production and the mechanism involved in milk secretion and the systems controlling milk letdown are so strong that may reduce milk secretion and subsequently result in reduced total milk yield and calf growth.

Table 6.20 The number of urban dairy farms using different calf feeding methods by cluster in the Harar milkshed

Cluster	Number of dairy farms	Suckling before milking	Suckling after milking	Suckling before & after milking	Bucket feeding
5	16	3	1	6	6
6	7	2	1	0	4
7	3	0	0	0	3
Overall	26	5	2	6	13

According to Knight *et al.* (1994) milk secretion is the process of manufacturing milk from the raw materials in the blood by the alveolar cells and the storage of that milk in the cavities of the alveolus (Matthewman *et al.*, 1993; Knight *et al.*, 1994). This is a continuous process, which only stops when the alveolar cavities are full and the pressure on the alveolar cells of the mammary gland inhibits further secretion. Milk ejection is the process through which milk is released from the alveoli and flows into the ducts, the cistern gland and the teat cistern of the mammary gland, from where the calf or the milker can remove it. Milk letdown is controlled by the hormone oxytocin, which is released as a reflex to natural stimuli (Matthewman *et al.*, 1993; Knight *et al.*, 1994).

The milk letdown reflex is activated by the action of suckling or udder massaging. This action sends messages from the nerve endings in the teat to the brain, situated at the rear end of the pituitary gland. The letdown hormone oxytocin is released into the blood and reaches the udder, causing the myo-epithelial cells, which surround the alveolus, to contract and force the milk into the ducts. Oxytocin in the blood does not last long and hence milking should start immediately (Knight *et al.*, 1994). If milking is inefficient and slow, not all the milk will get letdown and milked out. Matthewman *et al.* (1993) reported that 15% of the total milk volume usually remains in the udder after letdown and incomplete milking, which reduces the long-term yield performance. Excitement, stress, pain or fear will interrupt the milk letdown process through the release of the hormone adrenaline from the adrenal cortex which will completely block the action of the letdown hormone oxytocin. Stressful situations during milking need to be avoided to ensure smooth and complete milking of the mammary gland.

On the other hand, calves in the tropics mostly rely on feeds of low nutrient quality (Preston & Leng, 1987). Restricted suckling prevents the calves from feeding on milk rations only but still allow growth at a lower rate. Diets that would not support maintenance requirements if fed alone, should be avoided. The small quantity of milk that they consume bypasses the rumen completely, providing the calves with a balanced diet of essential amino acids, glucose and long-chain fatty acids (Preston & Leng, 1987). Several studies indicated that suckling increases total milk output from *Bos indicus* and their crossbred cows (Preston & Leng, 1987; Matthewman *et al.*, 1993; Tesfaye & Gebre-Egziabher, 1995; Das *et al.*, 1999; Sandoval-Castro *et al.*, 1999). Hence, those farms that did not use suckling or proper udder washing and massaging to initiate milk letdown in the current study, might be under-exploiting the milk production potential of their cows.

6.3.6.2 Bucket feeding

The amount of milk and the weaning age of calves in the urban dairy farms of the different three clusters of the Harar milkshed are shown in Table 6.21.

Table 6.21 The average amount of milk fed per calf and the weaning age for bucket fed calves in urban dairy farms of the Harar milkshed

Cluster	Number of dairy farms	Amount fed (liter)	Weaning age (months)	Milk fed per calf per day (liter)
5	16	300^a	5.0^a	2.0
6	7	580^b	4.0^b	4.5
7	3	410^c	4.0^b	3.4
Overall		430	4.3	3.3

a, b, c Means with different superscript in the same column differ significantly ($P<0.05$).

In the three clusters, calves were fed an average 430 liter of milk, were weaned at 4.3 months (about 129 days) of age and received about 3.3 liter of milk per day until weaning. However, clusters were differed ($P<0.05$) in the amount of milk fed and the weaning age of the calves. Calves in Cluster 5 were fed significantly ($P<0.05$) lower amounts (300 kg) of milk and were weaned at a significantly ($P<0.05$) older (5 months) age. Calves in Cluster 6 were fed a significantly ($P<0.05$) larger quantity of milk compared to calves in Cluster 5. This system of calf rearing is common in Ethiopia and has been noted very often in the available literature for small-scale farms (IAR, 1976; Mulugeta, 1991; Tegegne *et al.,* 1990). This method of calf rearing generally offers the calves a relatively large proportion of the milk produced and lowers both total milk harvested and milk that can be sold especially under small-scale farming conditions. The quantity of milk offered and the weaning age of calves vary among the various institutes, organizations and private dairy farms in Ethiopia. Most of the calf feeding systems practiced by dairy farmers are based on large amounts of milk offered to calves (from 380 to 680 kg) and the calves are weaned from 6 to 8 months of age, which makes it uneconomical (IAR, 1976; Mulugeta, 1991; Tegegne *et al.,* 1990). The Ministry of Agriculture advises that crossbred calves should receive colostrum for the first four days and 2.6 kg/day of milk until weaning at 84 days of age (MOA, 1983).

The Australian Agricultural Consulting Group and Management Company reported that in some cooperative farms, it appears that the consumption of milk per crossbred calf ranges from 380 to 520 liter and weaning occurs around four months of age. The Institute of Agricultural Research (IAR, 1976) reported that the quantity of whole milk suckled by calves at Adami Tulu and Abernosa over 181 days was 682.3 kg, which is equivalent to 3.8 kg/day. On the other hand Yousuf *et al.* (1987), Goshu *et al.* (1989) and Tegegne *et al.* (1994) have noted that developing small-scale dairy production systems based on crossbred dairy cattle, posed difficulties in management of these improved calves under farmers' conditions. Animals with a high amount of exotic Friesian blood levels (50% to 80%) were found to have difficulties in management, mainly because these calves were unable to bear post weaning environmental stresses, most importantly the poor nutrition provided to them (Yousuf *et al.,* 1987; Goshu *et al.,* 1989; Tegegne *et al.,* 1994).

Almost all the calf rearing systems discussed are not economical, especially when recent developments in calf feeding are considered. For example, a study at ILCA indicated the possibility of weaning bucket-fed crossbred calves within 8 weeks of age with less than 200 kg of milk (ILCA, 1991). Preston (1967) recommended that early weaning should take place at 3 to 5 weeks of age. Under small-scale dairy production systems, both total and salable milk yields are low because of the high level of milk fed to crossbred calves. Reducing the weaning age would allow the small-scale dairy farmers to get additional milk either for family consumption or for sale. Leaver & Yarrow (1972) noted that weaning as early as possible reduces the risk of diseases related to milk feeding and saves on feed and labour. Maintaining high milk yields through a high level of input, such as feeding a high proportion of concentrates, may be beyond the reach of the small scale farmer. A reduction in the quantity of milk consumed by calves without affecting their growth performance may be possible through a reduction in weaning age, improvement of exotic blood levels, by the incorporation of cheap solid feeds or the use of skim milk and whey (Kurtu *et al.*, 1993; Capper *et al.*, 1992). These may be worthwhile alternatives to pursue.

From the above discussion it can be concluded that the calf rearing methods practiced in the urban dairy farms of the Harar milkshed, is characterised by feeding too large quantities of milk over a relatively long period. This method substantially decreased the total milk off-take and milk sold. Hence, current calf rearing methods were found to be one of the dairy management aspects that limit milk production and need to be considered in future dairy development strategies for the Harar milkshed.

6.3.7 Housing and barn cleaning frequency

The types of housing for dairy cattle in the urban dairy production sub-system in the Harar milkshed are shown in Table 6.22. All the farms housed their crossbred cows in barns with a roofed shelter, equipped with a feeding trough but the housing type and the costs involved varied. Four types of housing were found. Type 1 is a roofed structure and plastered with mud (*chicka*); Type 2 is a roofed structure with corrugated iron sheet walls; .Types 3, 4 and 5 are roofed structures with hollow blockwalls, varying in ventilation from poor to good and very good. About 35% of the dairy cattle were housed in barns of Type 1, whereas 27%, 15% and 15% of the dairy cows were housed in barns of Types 2, 3 and 4, respectively (Table 6.22).

About 66% of urban-dairy farms which had Type 1 barns (poor type) were from Cluster 5, followed by about 22% of dairy farms in Cluster 6 and 11% in Cluster 7 respectively.

These barn types differ mainly in the type of wall and facilities like ventilation, gutters and light, which influenced the cost of construction. Barns with both wooden frames and plastered with mud, locally called "Chicka" walls or corrugated iron sheet walls cost less than 50% than cattle barns with hollow block walls. Thus, small-scale farms normally find it difficult to have such expensive barns owing to the financial limitations they have. There is a broad scope of environmental factors, such as pathogenic organisms, temperature and humidity that have an impact on the health and performance of dairy cattle as a result of housing and management (Albright & Allison, 1971).

Table 6.22 The number and proportion of urban dairy farms using different types of housing for cows by cluster in the Harar milkshed

Type	Cluster 5	Cluster 6	Cluster 7	Housing type (%)	Estimated cost Birr
1	6 (37%)	2 (29%)	1	35	313
2	2 (13%)	-	-	8	215
3	3 (19%)	3 (43%)	1	27	477*
4	3 (19%)	1 (14%)	-	15	477
5	2 (12%)	1 (14%)	1	15	631
Total	16 (100%)	7 (100%)	3	100	

* Differences in the cost of the barn for hollow block types were due to lower and higher costs involved for private dairy enterprise & institutions' dairy farms respectively.

Type 1 Roofed, with feeding trough, no gutter "chicka" walls, poor light and ventilation.
2 Roofed, with feeding trough, no gutter "corrugated iron sheet" walls, poor light and ventilation.
3 Roofed, with feeding trough, hollow block walls with poor light and ventilation.
4 Roofed, with feeding trough, hollow block walls with good light and ventilation.
5 Roofed, with feeding trough, hollow block walls with very good light and ventilation.

The importance of proper livestock housing in the tropics, where diseases, temperature and humidity interact and cause stress on the animal cannot be over-emphasized. As Saloniemi (1980) points out, in conjunction with a good herd health management program, housing is a main determinant of productivity. The extreme effects of climate, such as heat or cold, could stress animals and expose them to illhealth. Protecting them from such hazards is essential. Factors of practical importance to consider in livestock housing are location, ventilation, roofs, walls, floor and internal facilities in the context of tropical climates (Slater, 1991). Appropriate roofing is required to protect animals from rain and prevent cold stress as well as for reducing heat loss during the night.

Good ventilation, with high enough roofs allows keeping the barn dry and cool by letting breezes blow through and releases heat, moisture and pollutants (Slater, 1991). A major problem in dairy herds during housed periods is a lack of sufficient space for each group of animals according to age and production (Martin, 1973) as shown in Table 6.23. More than 60% utilized cemented flooring and 31% of the farms used paved stone, while about 7% used uncovered soil for the barn's floor for dairy cows in the present study.

Table 6.23 Number of urban dairy farms using different barn floor types for dairy cattle in the Harar milkshed

Type of flooring	Cluster 5	Cluster 6	Cluster 7
Uncovered soil	7 (44)*	1 (14)	0 (0)
Paved with stone	1 (6)	1 (14)	0 (0)
Cemented floor	8 (50)	5 (71)	3 (100)
Total	16 (100)	7 (100)	3 (100)

* Values in parenthesis represent percentage.

About half of the dairy farms in Cluster 5 used cemented and paved stone, while the majority of the farms in Cluster 6 and all farms in Cluster 7 used cemented or concrete floor (Table 6.23). If properly designed cement floors are more hygienic and facilitate cleaning and drainage, compared to floors constructed with soil or with rough stone. However, high cost could be prohibitive for wider use of barn floors constructed of concrete under the small scale economic conditions.

The proportion and frequency of barn cleaning practices used by urban dairy farms in the Harar milkshed is shown in Table 6.24.

About 54% of the barns were cleaned once a day, while the remaining 46% were cleaned either twice or even three times a day (Table 6.24). About half of the dairy farms in Cluster 5 cleaned their barns once a day, while the majority of the barns in dairy farms of Cluster 6 and a few from Clusters 7 (30%) were cleaned once a day.

Table 6.24 The proportion of urban dairy farms using different barn cleaning frequencies in the Harar milkshed

Frequency of cleaning	Cluster 5	Cluster 6	Cluster 7
Once a day	8 (50)*	5 (72)	1 (33)
Twice a day	4 (25)	1 (14)	1 (33)
Three times a day	4 (25)	1 (14)	1 (33)
Total	16 (100)	7 (100)	3 (100)

* Values in parenthesis represent percentage.

The distribution of the barns for the urban dairy cattle and the separation of calves of the urban dairies in the Harar milkshed are presented in Table 6.25.

Table 6.25 Frequency distribution of farms according to crowdedness and the calf rearing system in the urban dairy farms of the Harar milkshed

Cluster	Number of farms	Crowdedness: Less crowded	Crowded	Very crowded	Separation of calves: Yes	No
5	16	6	8	2	9	7
6	7	2	2	3	5	2
7	3	1	-	2	2	1
Total	26	9	10	7	16	10

Unweaned calves were separated from their dams in about 62% of farms. Crowdness was worse on farms from Cluster 7 (66%), followed by those in Cluster 7 (43%) and Cluster 5 (12%). The lack of adequate spaces for the animals can cause serious management problems in that it creates problems associated with feeding and health conditions. As noted by Martin (1973) provision of group separation in terms of age and production and a provision of sufficient spaces for the different age groups, is probably the most important determining factor for the health and production performance. This means that, when animals are not provided with adequate space and separated in groups based on production and age, it tends to affect feeding levels and consequently may result in much lower production levels than expected.

It can be concluded that the majority of the dairy housing in the urban dairy production systems is of a poor type, affecting negatively the hygiene of the farm and animal health conditions especially in farms from Clusters 5 and 6. Housing of dairy animals in the urban sub-system of the Harar milkshed needs to be addressed as one of the most important limiting factors for the proper development of the dairy sector.

6.3.8 Manure production and utilisation

6.3.8.1 Manure production

From the survey results (presented in Chapter 3) it was indicated that cattle are the major source of manure in the study area. The mean number of adult animals per household in the rural and urban areas was 7 and 18 respectively. In addition to cattle, it was found that farmers also keep sheep, goats, donkeys and camels in some of the rural areas. The average production for cow manure per farm in the rural areas was estimated at about 117.6 kg fresh dung or 21.1 kg DM per day. An estimated 418.1 kg fresh dung or 75.2 kg DM of cow manure was produced per day per household in the urban dairy farms (Table 6.26).

Table 6.26 Estimated daily manure production per cow and per household in the different urban clusters of the Harar milkshed

Cluster	Number of farms	Number of mature cattle	Fresh manure/cow (kg)	Fresh manure/ household/day (kg)	Manure DM/household/day (kg)
5	16	129	24.1 ± 3.7^{a}	324.3 ± 33.2^{a}	63.2 ± 25.9^{a}
6	7	140	22.9 ± 4.1^{a}	638.6 ± 63.9^{b}	124.5 ± 32.9^{b}
7	3	149	19.7 ± 1.2^{a}	839.7 ± 98.8^{c}	162.7 ± 37.1^{c}
Overall	26	139	23.2 ± 3.8	491.4 ± 55.6	95.8 ± 37.1

a,b,c Means with different superscripts in the same column are significant ($P<0.05$).

Farms in Cluster 6 produced almost twice as much manure as farms in Cluster 5 and farms in Cluster 7 produced much more than those in Cluster 6 (Table 6.26). These differences are caused by the differences in the number of animals, feedings systems and feed intake in the different clusters. The amount of manure produced per animal, however, did not differ (P>0.05). Powel & Williams (1993) and Reynolds & de Leeuw (1995) noted that the amount of DM produced and the nutrient content of the faeces are highly influenced and dependent on feed intake and digestibility.

The mean daily cow manure produced by mature unimproved local cows was 16.8 kg or 3.0 kg DM (AUA, unpublished data, 2001) and the yield from crossbred cows was 23.2 kg or 4.2 kg DM under the feeding practices (Chapter 5) which is largely based on cut-and-carry in the rural and stall feeding in urban dairies. Similar results were obtained by Powel & Williams (1993) and Reynolds & de Leeuw (1995) who reported that matured cattle produce from 3.8 kg to 4.8 kg DM of manure per day. However, it has been noted that some of the manure produced on urban dairy farms was used for various purposes while the bulk was wasted.

It should also be noted that the manure produced by other classes of livestock such as calves and young replacement heifers was not quantified.

6.3.8.2 Manure utilisation

There is a variation in how the cow dung is being utilised in urban dairy production systems in the Harar milkshed (Table 6.27).

Table 6.27 The various forms of manure utilisation by cluster in the urban dairy farms of the Harar milkshed

Utilization	Cluster 5	Cluster 6	Cluster 7	Total
Wasted	8	5	2	15
Sold *	0	1	1	2
As fuel	4	1	0	5
Fertilizer	0	0	0	0
Biogas	4	0	0	4
Overall	16	7	3	26

* Sold to rural farmers to be used as fertilizer.

In the urban dairies about 58% of the dung is not used at all or wasted, 19% is used as fuel, 8% is sold as manure for crop farmers of the rural areas and about 15% is used for biogas production (Table 6.27). The majority of the farms in urban dairy areas are not wasting the manure but they are constrained with the disposal of manure. These farms are forced to pile the cow dung outside the farm, causing a nuisance to the area and predisposing the environment to pollution. A few (4%) farmers in Clusters 6 and 7 sell the manure for crop farming to the rural farmers and about 15% of the farms in Cluster 5 are using it to generate biogas for household use.

It was noted that those few farms which were easily accessible, were selling (exchanging) their dung for an equal quantity (one truck of dung to one truck of crop residues). This is actually an interesting phenomenon that tends to depict clearly a sort of complementarily relationship that exists between urban dairy and crop production systems in rural areas, but it is highly limited by the problems related to transportation.

In general, it can be concluded that cattle manure is an important resource that has already been recognised by the farmers in the study area. However, like in many mixed crop-livestock production systems of the world, manure remains an important organic matter resource in subsistence farming, the production, management and use of this resource seems to have received little attention and has not as such been adequately addressed, particularly in urban areas. In addition, the production and utilisation of the manure in urban areas and its relation to crop production in rural areas seem not to have been adequately addressed.

Furthermore, it was noted in the rural setting that farmers were mentioning the serious shortage of manure limiting crop farming, while in the urban areas the dairy farms were suffering from a lack of means of disposal and/or appropriate storage places for the excessive qualities of manure produced. In addition, manure storage, means of transportation, development of appropriate technology, such as biogas and means of disposal need to be looked into to make best use of manure and maintain and strengthen the already existing complementary relationship of the urban dairy and rural crop farming systems in the Harar milkshed.

This relationship, if maintained adequately would help in keeping the urban environment clean of livestock pollution and make the urban dairy production systems sustainable and prosperous in the Harar milkshed. In addition, the production and utilisation of the manure in the urban areas were found to be limited and one of the important causes of environmental pollution, threatening the continued prospects of dairy production in urban areas if urgent and appropriate corrective measures are not taken.

Thus, there are major problems requiring further consideration in terms of future research, such as manure storage systems, storage time and means of transportation that seemingly limit the effective use of dung in rural as well as urban areas. In addition, manure storage and means of transportation, development of appropriate technology such as biogas, and disposal means need to be looked into to make best use of manure and keep the environment clean, making urban dairy prospective in the milkshed.

6.3.9 Major health problems encountered by urban dairy farms in the Harar milkshed

6.3.9.1 Major diseases of crossbred dairy cows in urban dairy production systems

The distribution of major disease incidence in the urban dairy production systems in the Harar milkshed is shown in Table 6.28. The overall mean annual disease incidence was 80%; 33% for general diseases and 47% for reproductive diseases and mastitis. Differences between the clusters for the incidence of diseases were significant (X^2=22, $P<0.05$).

Table 6.28 Frequency distribution of the major diseases in different clusters of the urban dairy farms of the Harar milkshed

Cluster	Number of cows	Mastitis	Laminitis	Others[1]
5	99 (31%)	19 (19.2%)	10 (10.0%)	5.8 (5.8%)
6	115 (35%)	*24 (21.0%)	*11 (9.5%)	6.9 (5.9%)
7	109 (34%)	15 (14.0%)	2 (2.0%)	*12.7 (11.6%)
Overall	323 (100%)	58 (18.0%)	23 (7.1%)	25.3 (7.8%)

[1] Include: digestive and respiratory disorders.
*P<0.05

Placental retention and abortion were among the major reproductive diseases observed, representing about 69% of the remaining clinical cases reported. Other clinical cases, that include digestive and respiratory disorders, also occurred (7.7%). A similar finding was reported by Feseha (1997).

Except for reproductive diseases, overall annual disease incidence was 33%. The frequency of this disease incidence in the three clusters were about 35, 36 and 27 % for Clusters 5, 6 and 7 respectively and the differences were significant (X^2=8, 11 and 9 for Clusters 5, 6 and 7 respectively). The frequency of incidences of mastitis in all three clusters was 18%. This mastitis incidence was almost similar (20%) for cows in Clusters 5 and 6 but more frequent than for cows in Cluster 7 (Table 6.28). Mastitis and reproductive problems were more frequent in cows in Clusters 5 and 6 compared to cows in Cluster 7.

The incidence of laminitis was less frequent in cows in Cluster 7 compared to cows in Clusters 5 and 6. This lower incidence in Cluster 7 could have been the result of the lower intake of high energy feeds, mainly industry brewery waste (IB) (which was the main energy source) compared to cows in Clusters 5 and 6. Available literature indicates that laminitis is usually associated with lactic acidosis where cattle are being fed with a high amount of energy in the diet (Van der Merwe, 2000). Overall reproductive disease incidences were about 47%. Differences were significant (X^2=22, $P<0.05$). The means of annual reproductive disease incidences were 47, 59 and 33% for Clusters 5, 6 and 7 (X^2=7.8, 11.4 and 21.6) respectively (Table 6.29). Mean frequency of incidences of placental retention and abortion were about 23 and 18%; 28 and 22%; and 12 and 12% respectively for Clusters 5, 6 and 7, respectively.

Table 6.29 Frequency distribution of the most important reproductive problems per urban dairy cluster in the Harar milkshed

Cluster	Number of cows	Stillbirths	Abortions	Placental Retention
5	77	4.85 (6.0%)	*13.70 (17.9)	17.80 (23.0%)
6	74	*7.19 (9.7%)	16.00 (21.6%)	*20.94 (28.3%)
7	73	6.70 (9.1%)	8.50 (11.6%)	9.00 (12.0%)
Over all	224	18.74 (8.3%)	38.20 (17.0%)	47.74 (21.3%)

* P<0.0.5

The differences were significant (X^2=4.8; and 2.3 respectively) for placental retention and abortion. Differences for stillbirths were not significant ($P>0.05$, X^2= 0.48). The relatively higher frequencies of reproductive diseases and clinical mastitis in the dairy herds have also been reported by Bekele *et al.* (1991), Bishi (1998) and Lema *et al.* (2001) in dairy herds of the Addis Ababa area.

The higher frequency of occurrence of the diseases in Clusters 5 and 6 compared to the specialised dairy herds in Cluster 7 may be owing to a low level cleaning of the barn, low level of hygiene exercised, more crowdedness and other poor management practices. The lower frequency of diseases in the larger herds may be explained by the fact that better management was employed owing to more available resources, skills and knowledge than in the resource poor farms.

The slightly higher disease frequencies in Cluster 5 (UIRP) and Cluster 6 (UMRDS) compared to Cluster 7 (SPUD) may be the result of growing management pressure and the increasingly unfavourable production conditions in these areas. For example animal housing, labour and methods of production might have become more intensive making it unable to compete for the resource poor farmers. Furthermore, farm owners in Clusters 5 and 6 might have opted to employ cheaper labour whose standard of hygiene might be low to the extent that the farms are more prone to diseases in both animals and humans and may be conducive to the transmission of zoonotic diseases. This is supported by Staal & Shapiro (1995). Abortion is an important cause of poor reproductive performance. Brucellosis is generally assumed to be the major cause of abortion and this is a zoonotic disease that also infects humans who consume raw contaminated milk. Abortion may also be caused by mechanical factors.

There were a total of 26 deaths of which 19 were calves. Mortality rate was 4.5%. Three cows died of digestive disorders (1.33%), two cows of reproductive diseases (1%) and one heifer (0.004%) from other infectious diseases. Calf scour was the major cause of mortality among the calves. Similar findings were reported by Nesru (1998) in Ethiopia and Pijeoan (1997) in Mexico. They identified pneumonia and scours as major causes for calf mortality. These diseases are indicators of poor hygiene and overcrowding of calves as well as poor colostrums management.

Finally, the incidence of diseases in the herds would have been much more than what has been presented if sub-clinical situations were considered. The present results indicate that reproductive and mastitis problems were the most frequently occurring diseases in cows of urban dairy farms of the Harar milkshed and the economic importance warrants further consideration in future studies.

In conclusion, a very high disease incidence (80%) was recorded for urban dairy farms of the Harar milkshed. Mastitis and reproductive problems were identified as the most frequently occurring diseases for cows and diarrhea and pneumonia were the most important calf diseases. Farms in Cluster 7 were found to have lower disease incidents compared to farms in Clusters 5 and 6. The lower disease incidents recorded for Cluster 7 might have been because of better housing facilities and management practices employed compared to the farms in Clusters 5 and 6. Therefore, these disease incidences, mainly mastitis and reproductive problems are identified as important problems (probably brucellosis, a dangerous zoontic disease) challenging urban dairy production systems in the milkshed and need to be addressed adequately in future dairy improvement strategies of the Harar milkshed.

CHAPTER 7

DISTRIBUTION, MARKETING AND PROCESSING OF MILK IN THE HARAR MILKSHED

7.1 INTRODUCTION

In Ethiopian highlands as well as in the lowlands, livestock is an important component of the mixed, subsistence farming systems. The milk produced by small-scale dairy farms in Ethiopia is sold and/or consumed as fresh or fermented milk or processed into products such as butter, ghee and cheese (O'Mahony, 1988; O'Connor, 1994). Cows are the main source of milk, representing 83.4% of the total annual milk output (FAO, 1993). In the Harari region however, camels are also an important source of milk for human consumption, where a large segment of the population, particularly the Muslim communities, use it regularly (Zeleke, 1998; Tezera & Bruckner, 2000). The population of Harar town relies on several sources of milk supplies, namely urban and peri-urban, rural small-scale milk producers and to a small extent, commercial dairy farms and imported powder milk. Milk sales by urban, peri-urban and rural milk producers is largely determined by the proximity, reliability of market outlets and the prices obtained (Staal *et al.,* 1997).

Sour milk is the most common product and milk is usually soured before any further processing is done. There are a few milk-processing plants in Ethiopia, but most of the milk produced by rural small-scale dairy farmers is processed on farms using traditional technologies (O'Mahony, 1988). These traditional milk processing technologies are generally time consuming. It is also inefficient in terms of value adding and milk fat recovery turned into butter per unit of milk processed. In addition, the quality of the products is in general poor, resulting in a comparatively short shelf-life and a lower price for the milk producer (ILCA, 1992). It is important to assess the milk delivery and processing methods and look into possible technological interventions in order to improve and promote dairy production at household levels in the rural sector. As the traditional sector comprises the largest part, accounting for over 97% of the total milk production in the country (Abaye *et al.,* 1989), improvement of this particular sector is important for higher production and supply of dairy products to the urban consumers.

The objective of this section of the study was therefore to analyse milk preservation, delivery, marketing and processing systems and determine the major constraints limiting the small-scale dairy production in the Harar milkshed.

7.2 MATERIALS AND METHODS

A questionnaire based survey was conducted in the Harar milkshed, involving 200 rural and 50 urban dairy producing households. Details of the survey procedures are given in Chapter 2. Three market sites were selected for the study, namely Hara, Bisidimo and Babile (Erer, Kore) on recommendation of the Agricultural Bureau of the region. To assess the milk marketing, delivery and processing methods, a structured questionnaire was used (M.Y. Kurtu, 2003; unpublished data). Milk marketing was monitored by visiting these market sites once a month during a period one year. The data collected included the amount and price of milk available every month. The survey aimed at identifying the major constraints in milk marketing at each site. The data was analysed using SPSS (1995) and ANOVA procedures SAS (1989). The survey was conducted between January 2001 and January 2002.

7.3 RESULTS AND DISCUSSION

A selection of aspects discussed in this study is shown in Chapter 9 (Compilation of photographs).

7.3.1 Milk handling and preservation

Traditionally, milking and processing are the tasks of women of each family particularly in most rural highlands of Ethiopia (Brokken & Senait, 1992). All the interviewed farmers practice hand milking as it is done throughout rural Africa (Brokken & Senait, 1992). The female members of the households (wives and daughters) are usually responsible for milking and performing milk processing activities. However, sometimes when the women are not around or engaged in other activity men also milk and process it. The survey showed that cows of all breed types, local as well as crossbred cows are milked twice a day in the morning and evening except for the low milk producers. The latter cows are milked only once a day, usually in the morning. Milking three times a day was observed in only one farm for a few exceptionally high yielding cows in the urban area. This is supported by

Fekadu & Abrahamsen (1994) who observed milking three times per day in other places of the Ethiopian highlands. Milking usually is not complete in order to leave some milk for the calf in most farms, even in the urban dairy system. A similar finding was reported by Brokken & Senait (1992) in the central highlands of Ethiopia.

In most of the rural areas surveyed, the milk equipment was generally washed with clean water and some herbs of a special plant material used as disinfectant. These herbs or plants locally are called 'Beka Arkate' (*Lantana kamara*). The equipment is also smoked with various plants in order to clean the equipment and avoid any microorganisms that spoil milk. The plant materials used for smoking were "Ejersa" Olive plant or the previously mentioned *Lantana kamera*. Smoking of milk containers is used as a preservation method among farmers in almost all the surveyed areas, including the urban dairies. This was also a common practice in Somalia (Mohammed *et al.*, 1990).

In rural areas like Anood and Awsharif FAS, the night milk is some times boiled before it is mixed with the morning milk, as a preservative method but the morning milk is not boiled. The morning milk is not boiled because of the little time they have before going to the market place. These farmers believe that boiling the night milk has helped them quite a lot in preserving milk during marketing, even though occasionally it was observed that the boiled night milk, after mixing it with the morning milk, was spoiled in the market.

Milk is collected in the guard/the churn and fermented for butter making and usually takes 2-3 days in the lowlands and highlands respectively. In the rural areas of the Harar milkshed it is not common to sale fermented milk. However, in urban areas there was only one smallholder who was fermenting milk for sale. Normally, none of the urban dairies make butter for sale. Occasionally when the need arises and if excess milk is left unsold due to various reasons that include the fasting period of Orthodox-Christian during which milk becomes surplus, it is fermented. All those farmers interviewed preferred to sell fresh milk because of the high demand for fresh milk and the less labour involved.

7.3.2 Milk marketing and delivery systems in the Harar milkshed

There were generally three different milk outlets or delivery systems identified, namely traditional milk associations or groups, milk collectors (traders) and the producers themselves (Table 7.1). On average, the delivery of milk by milk associations or groups was the dominant feature, followed by direct sales of producers and individual collectors or traders in the rural areas of the Harar milkshed. The delivery systems, however, differ between the locations depending on the distance from the market sites. In the rural Harari region, about 66% of the farmers deliver milk through a milk association and 34% deliver milk on their own. In the Babile and Bisidimo areas, 75% use the services of milk associations and 13% sell it themselves or use individual collectors. All delivery of milk was done by women in the rural areas of the Harar milkshed. In the urban areas, however, all farmers deliver milk to consumers on their own.

The survey showed that milk marketing in the Harar milkshed is predominantly an informal one and is defined as a traditional milk marketing system that involves the direct delivery of raw milk most fresh milk, but also some sour milk by the producers to the consumers in the Harar town or to the immediate neighbourhood as well as to roving traders or individuals in nearby towns. The informal milk marketing in the rural areas have different features, which seem to be unique to the Harar milkshed when compared to any other part of the country and each delivery system is defined and discussed below.

Table 7.1 Geographical distribution and main types of milk outlets in the Harar milkshed

Households	Milk associations or groups	Milk collectors	Direct sales by producers**
Rural Harari	80	-	40
Babile and Bisidimo*	60	10	10
Urban dairy	-	-	50
Total	140	10	100

*Babile and Bisidimo are towns in the Oromia region within the Harar milkshed.

** By a member of the household who generally is a woman.

7.3.2.1 Milk delivery associations (Faraqa Annanni)

This is a unique self-initiated and organized group of women with the objective of facilitating the interaction and milk delivery processes among rural women groups. This involves a group of 5 to 15 or more women from one village who have milk cows and join resources for milk delivery or sale to the market. The system operates in such a way that the milk contributed from each member will go to one member each day in turn. The same member who receives the contributed milk delivers it to the market and uses the income generated. An individual member contributes with whatever amount she wishes to be put out for sale, but gets back an equal amount that has been contributed by each member when it comes to her turn.

This practice is very common, especially in the Harari region. Generally, the rural households believe that this system has several advantages. It saves time from daily trips to the market to sell milk that usually do not exceeds three liter. Instead, members can go to the market only once a week or once a month, depending on the size of the group. This system also provides the household with an opportunity to plan for the purchasing of some items that require a relatively large amount, which otherwise would not be possible if the income was generated on a daily basis. There also seems to be a sort of regularity of weekly, bimonthly or monthly income that would enable the household to plan better for its future needs. Farm Africa (1996) has reported the same practice in eastern Hararghe.

7.3.2.2 Milk woman/milk collector

There are individual women in rural areas who deliver milk to the market on the basis of certain informal contractual agreements entered into with the milk producers. In this contract, the milk delivered will be marketed and the income will be brought to the producers on a daily basis. The milk owner or producer agrees to give her one day's of milk income for every three days of sales or delivery. However, if the milk spoils during the delivery the losses will be borne by the so called "milk woman". The milk women normally will enter into a contract agreement with 5 to 6 individual producers or farmers enabling her to carry about 17 to 18 liter every day. The milk women sell milk to consumers on a cash basis and it is normally sold to the nearest market in Bisidimo town and the price is lower (Birr 1.5/l) compared to that price (Birr 2.5/l) in Harar.

7.3.2.3 Individual producers/households (direct sales)

This normally happens in urban areas and in some rural areas when the distance between the farm and the market is not big (not more than 3 km). In urban areas both women and men sell milk depending on the owner of the farm but for rural areas milk sales are done normally by women.

Of all the above-mentioned forms of milk delivery systems the milk delivery group or associations seem to be more important. However, this needs to be examined further so that the major constraints and problems are identified. This could help the groups to organise themselves in a better and more efficient way. The groups will have to be supported by governmental and non-governmental development agencies in the area so that the small-scale dairy farmers achieve a better position in the market and they can become more marketoriented dairy farmers and enhance their income from milk sales.

7.3.3 Milk marketing channels and the role of retailers

Almost all the milk groups or individual milk producers, especially those located at a considerable distance from the market places (towns) usually deliver their milk to a retailer in the nearby market that subsequently takes the milk to the consumers in Harar town. This channel also has two different forms depending on the kind of agreement the producers enter into with the retailer women.

Type one: The milk is handed to a retailer (milk women) on a credit basis and the producer collects the money only when the milk is sold. A retailer who delivers the milk to the final seller in Harar town does the delivery of milk covering the transportation costs. There are about 5 to 10 such retailers (milk women) in Bisidimo town. The retailers, especially during the dry season, blend the cow milk with camel milk in a ratio of 3:1 before the milk is delivered to the Harar town market. This is done because camel milk is in lower demand and fetches lower prices compared to cow's milk in the market. Hence retailers can get better profits by this practice. On the other hand, if the milk is spoiled or is late owing to transportation problems, which often occur, it is only the producers who bear the total risk. During a period of one month it was recorded that there were four cases with one individual farmer complaining of total loss of milk because of spoilage during delivery before reaching the Harar market. Similarly, two cases of absence of transportation or arriving late by about 15 hours were reported. This subsequently resulted in selling of all milk to the Bisidimo town dealers for a cheaper price (one Bir/liter for cattle and 0.5 Birr/liter for camel milk instead of 2 Birr/liter).

Type two: The retailer (milk women) enters into a contract with the producer or the rural milk association to collect, deliver and sell the milk to Harar consumers. In return the milk women will have one day's milk income for every three days' sales. Here there is no risk that the farmer bears all the transportation costs and losses owing to spoilt milk. These costs are totally carried by the retailer (milk women). Normally, it is the retailer herself that takes the milk to Harar town for sale and usually the quantity is relatively smaller than in the previous (type one). This type is more common in Babile and its surroundings (Erer and/or Kore), than in the Harari region.

To protect the producers from market associated risks and to secure the benefits of the producers so that they are encouraged and motivated to produce more, there is a need to design some means of promoting and up-grading milk delivery associations. Efforts must ensure that the delivery of milk to target consumers in Harar town is done at a minimum cost. Currently, the government in some parts of Ethiopia is making efforts to promote milk marketing systems in rural areas. For example, the Ethiopian Ministry of Agriculture's Small-holder Dairy Development Project (SDDP), supported by the Finish International Development Organization, has formed a dairy farmers' association which recently established milk-marketing co-operatives. The milk groups buy milk from both members and non-members, process it and sell the products to traders and local consumers. Although the milk groups sometimes sell liquid milk products such as sour milk, skim milk or buttermilk, most of their revenue is generated by sales of processed dairy products, like butter and cottage cheese (Staal *et al.,* 1997). However, what is required here is not to copy this system as it is, but to build on what is already existing (indigenous knowledge) with the same objectives, and if possible with a higher efficiency.

7.3.4 Daily milk sales and seasonal fluctuations in Bisidimo and Babile

There were on average a total of 375 and 685 liter per day of cattle and camel milk respectively from Babile. The corresponding quantities for Bisidimo were 840 and 523 liter per day respectively. There was a clear fluctuation of milk sales in amount and type over the different months of the year (Figures 7.1 and 7.2).

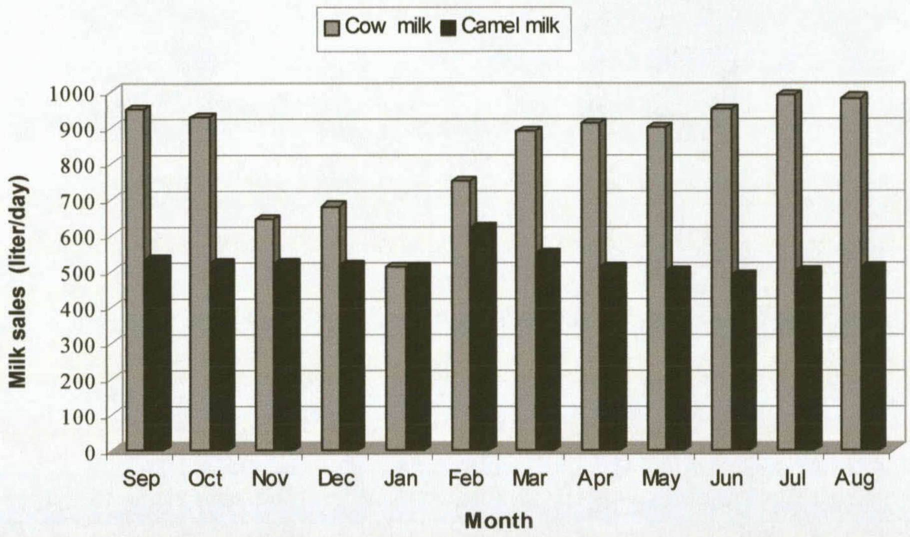


Figure 7.1 **Cow and camel milk sales by households in the Bisidimo market, 2001/2002**

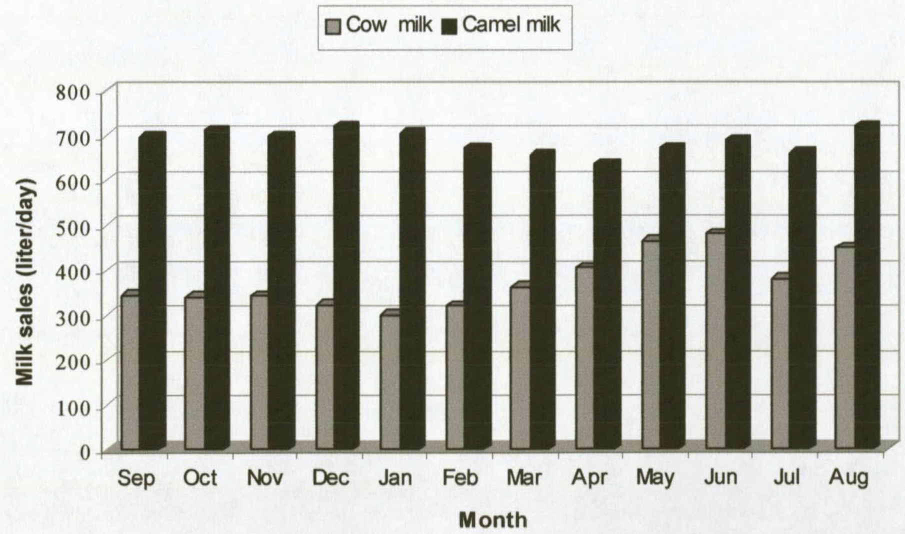


Figure 7.2 **Cow and camel milk sales by households in the Babile market (Erer & Kore, 2001/2002)**

In both market places the total milk sales were lower between October and February (during the dry season) and relatively higher during August and September (wet season). The highest cattle milk sales in Bisidimo were in July and the lowest were in January. The highest cattle milk sales in Babile (Erer & Kore) were in August and the lowest in January. This is a clear reflection of the seasonal fluctuation on the feed available for the dairy animals. There was more camel milk offered in Babile compared to Bisidimo.

The camel milk sales show an increase during the dry season and relatively lower sales during the wet season. This may be due to of the fact that camels can survive and produce more milk than cattle during the dry season. In addition, farmers have a better chance to sell more camel milk during the dry season and more cattle milk during the wet season to meet the market demand. It is noteworthy how the camel milk tends to serve as a buffer during the dry season when cattle milk is in short supply. These finding are in line with those of Zeleke (1998) and Tezera & Bruckner (2000).

7.3.5 Milk price in the various markets

The proportion of milk delivered, the distance from Harar town and the price of milk and butter during different seasons are presented in Table 7.2. The price change across the various market sites tends to vary as the relative distance from Harar changes. The milk price in Harar was the highest and ranged between Birr 2-3 per liter, during the wet and dry seasons respectively, and the lowest price was recorded in Bombas town which had a range of only Birr 0.5-1 per liter of milk during the two seasons.

The transportation costs involved also show a similar trend in that if the market site is far from Harar, the cost of transportation also increases. Places far from Babile, such as Bombas, because of the long distance involved and the high transportation costs required, do not deliver milk to Harar town despite the lower prices of milk. No retailers seem be interested to collect milk from Bombas and deliver it to Harar town. The transportation cost seems to have prohibited these farmers to participate in a market oriented milk production system. This has been noted by Staal *et al.* (1997) in some of their studies in the highland of Ethiopia, particularly around Addis Ababa.

Table 7.2 The household milk and butter sales and distances from the Harar market

Sources	Distance from market (km)	Price of milk/kg (Birr)*	Cost of transportation (Birr)	Cost of butter/kg
Harar	0-5	2.50-3.00	0.5/5liter milk 4/person	30-40(33%)
Bisidimo	21	2.00-2.25	0.5/5liter milk 6/person	24-30(25%)
Babile**	35	1.50-1.75	0.5/5liter milk 7/person	17-20(18%)
Bombas	55	0.50-0.75	13/person	12-18(50%)

* Price differences representing wet and dry seasons respectively.
** Babile includes Erer and Kore, major milk marketing sites on the road to Babile.

Even though there are many barriers to market milk from the rural areas, particularly the distance, risks associated with milk being a perishable item and the cost of transportation involved may be the major restrictions for small-scale farmers. The rural households in remote areas beyond a 14 km radius, particularly in the Bisidimo and Babile areas, were not able to deliver milk to the market sites due to lack or high cost of transportation. These households were limited only to processing and selling milk products in the form of butter and ghe. Large enterprises have no problem with collecting and transporting large volumes of milk. Staal *et al.* (1997) have promoted similar views and concluded that the existence of relatively high marketing costs for liquid milk in Africa and the risks attached to marketing perishable products in the tropics, suggests that transaction costs play a central role in limiting dairy production and marketing. Under such conditions, producer-marketing co-operatives that are able to market larger volumes and sufficiently reduce transaction costs may enhance market participation. Hence, it is vital to know what governments can do to better support these emerging organisations and determine which institutions should be supported.

7.3.6 Relative efficiency of traditional milk processing techniques

7.3.6.1 Churning equipment and techniques

The equipment used to churn the milk are locally called *Rastu* or *Diro* which means churn. The equipment varies from a gourd to a simple plastic container. The estimated mean capacity of the equipment was 3.47 liter for both rural and urban dairies (Table 7.3). There was a highly significant difference (P<0.01) in the size of the equipment in the different locations. Smaller churning units were observed in the rural areas of the Harari region while larger ones were observed in urban areas. In general, the size of equipment ranges from 1 to 7 liter. The churning equipment in the rural areas consisted of a gourd with a capacity of 1 to 5 liter.

Table 7.3 Estimated time and quantity of milk/kg butter produced using traditional churning methods in the Harar milkshed

Location	Number of farms	Quantity of milk/kg butter (liter)	Churning time (minutes)	Capacity of equipment (liter)
Highlands				
Awberkaley	20	17.9 ± 1.3^{cd}	104.1 ± 17.3^{cd}	2.0 ± 0.4^{ef}
Deretayara	20	19.7 ± 1.1^{b}	122.5 ± 26.5^{b}	5.2 ± 0.3^{g}
Galmashira	20	18.8 ± 1.9^{bc}	122.5 ± 25.5^{b}	1.3 ± 0.3^{g}
Lowlands				
Anood	20	16.7 ± 1.3^{e}	88.9 ± 11.5^{de}	4.8 ± 1.2^{c}
Awsharif	20	18.6 ± 1.3^{c}	86.3 ± 20.1^{e}	5.7 ± 1.0^{b}
Berkaley	20	16.7 ± 1.3^{e}	109.0 ± 18.6^{bc}	4.1 ± 1.1^{d}
Burka	20	17.1 ± 2.0^{de}	87.8 ± 3.8^{e}	2.5 ± 0.6^{e}
Erer	20	17.9 ± 2.0^{cd}	113.5 ± 23.0^{bc}	1.5 ± 0.4^{fg}
Ifadin	20	16.9 ± 1.3^{de}	70.5 ± 15.7	5.2 ± 1.2^{bc}
Kile	20	16.3 ± 1.8^{e}	116.0 ± 26.4^{bc}	2.3 ± 1.4^{e}
Urban dairy	50	22.6 ± 1.8^{a}	203.1 ± 53.6^{a}	7.6 ± 1.5^{a}
Overall mean		18.1 ± 2.4	111.3 ± 22.0	3.5 ± 2.2

*a, b, c Means with different superscripts within columns differ significantly (P<0.05).

It was noted that the Ifadin FAS had a short churning time of only 70 minutes compared to the long period of 203 minutes for the urban dairies (Table 7.3). The longer time recorded for the urban dairies could probably be explained by the larger equipment that they use and also poorer churning skills among the urban farmers.

The equipment did not have any stirring device as often is the case in other parts of the Ethiopian highlands (Zelalem, 1991). Almost all the highlanders (Galmashira, Deretayara, Awberkale FAS) used a gourd with a smaller (1 to 2 liter) capacity compared to the lowlands. Churning was performed by lifting the equipment up and down after placing the equipment on slabs and holding it at an inclined position about of 60°. These processes continue until fat globules are formed. In the lowlands (Anood, Awsharif, Barkaley FAS) the type of churn used is the same, but it is a bit larger (4 to 6 liter). The churning style here tends to differ slightly from that in the highlands. In the lowlands, the churn is placed on the floor and kept continuously rocking back and forth to promote a continuous agitation until the fat globules are formed. In the urban areas a plastic container is used with an even larger capacity (up to 7 liter) compared to the rural areas. An almost similar churning style to that of the lowlands is used. Generally, the churning practices used in the Harar milkshed differ from those observed elsewhere in the highlands of Ethiopia (Zealem & Ledin, 2000). These researchers conducted their studies in the Salale and Holeta areas from which they reported different churning practices in terms of the material of the equipment, capacity and to a certain extent the style of churning compared to the present study. According to their report, both the Salale and Holeta areas used clay pots with capacities of 5 to 7 liter. Some of these churns were equipped with an internal stir (*Mesbeka)* to enhance agitation and formation of butter and three churning methods are used. Two of the methods were similar to the present study whereas the third one was different. The major difference noted in the milk processing techniques was the involvement of a stirring device to promote agitation, while in the current study the stirring device is missing. This seems to have an advantage for the future endeavors of dairy technology improvement perspectives, especially in the rural areas.

7.3.6.2 Churning time and efficiency

Churning time and amount of milk required were significantly ($P<0.01$) different across locations (Table 7.3). Generally, a shorter time and a smaller amount of milk required per kg of butter were noted in the lowlands, compared to the highlands.

Overall estimates were 111.3 minutes and 18.1 liter for churning time and the amount of milk/kg butter respectively, including the urban dairies. Average churning time for the rural area was about 101.8 ± 17.8 minutes and 17.6 ± 1.2 liter of milk per kg butter. A shorter time for churning and a lower amount of milk per kg of butter were reported for the lowlands (Ifadin, Anood, Awsharif and Barkaley FAS). A shorter time (70 minutes) for Ifadin FAS and a longer time (203 minutes) for urban dairies were observed. A relatively longer time (25%) and an increased amount of milk necessary to produce one kg of butter (8.4%) were reported for the highlands (Galmashira, Deretayara and Awberkaley FAS). The differences between the highlands and the lowlands for churning time and amount of milk required per kg butter were significant (P<0.01). The lesser time for the lowlands may be in part attributed to the churning processes that included the type of equipment and temperature (O'Mahony & Ephraim, 1985; O'Conner, 1994) and the churning skills as expressed by the interviewed households. A higher (67% and 47%) fat recovery was obtained with a churning temperature of 18 and 25°C respectively (O'Conner, 1994). On the other hand, the churn type can make a difference in the churning efficiency in terms of time and the amount of milk required per kg of butter. When the churn is equipped with an agitator, for example a local clay-pot churn with an internal agitator, introduced by ILCA gave improved results of 71% to 93% for fat recovery (O'Mahony & Ephraim, 1985). This is because an increased degree of agitation reduces the churning time (O'Connor, 1994). In addition, the interviewed households in the lowland (Ifadin FAS) claimed that the style of churning requires a skill for efficient butter making, thus, it seems that the lowland households are better skilled than their counterparts in the highlands. For butter production the average churning time reported in the present study (100 minutes) is less than the average traditional methods (222 minutes) reported by Zalelem & Ledin (2000). In addition, the traditional processing methods reported in the present study shows that about 4 liter less milk are required compared to the 21 liter suggested by Zelalem & Ladin (2000) in the Salale and Holota areas. This could perhaps be due to differences in milk composition (fat content) caused by breed differences as well as the quality of feed involved. Milk from the local cows has a higher fat content than crossbred or pure exotic European breeds (O'Mahony & Peter, 1987; Zinash *et al.*, 1988). The highest efficiency in terms of time required and the amount of butter obtained per unit of milk was observed in Ifadin, Anood and Barkaley FAS, followed by Burka and Awberkaley FAS and finally by urban dairies. Furthermore, the efficiency reported in this study was higher compared to the results obtained by Zelalem & Ladin (2000) in the Salale and Holeta areas. This may be due to the fact that the present study is based on the survey of the households' perception, which requires further research consideration to supplement these findings. However, both surveys (rural and urban) households highlighted milk delivery, processing and marketing problems pertaining to the need for more technical assistance aimed at the small-scale farmers' specific requirements. Socio-economic obstacles and dairy marketing systems have to be addressed if milk production is to be increased and sustainable dairy production systems in the Harar milkshed are desired.

7.3.7 Major constraints for milk marketing in the Harar milkshed

The major constraints identified by the farmers for milk marketing in the Harar milkshed are presented in Table 7.4. The majority (72%) put transportation problems first, followed by risks involved (12%) (souring of milk, losing money by dishonest retailers) and the remaining 16% cited lower prices and other constraints.

Table 7.4 Major constraints for milk marketing in the Harar milkshed according to farmers' perception

Sources	Transportation	Risk involved	Low Price /l milk	No problem	*Others
Rural Harari	101	-	-	19	-
Babile and	-	-	-	-	-
Bisidimo	59	21	-	-	-
Urban dairy	20	10	5	-	15

* Includes a lack of organisation or association, lack of technical knowledge and equipment and shortage of capital.

These constraints can be alleviated by combined efforts, especially upgrading and promoting the already existing milk co-operatives and supporting it by providing appropriate transportation means, including animal power where ever appropriate. It also requires the government intervention in terms of providing equipment, appropriate technology and required skills to enhance productivity and encouraging producers to increase dairy production in the area. This in turn requires an indepth study to come up with a viable intervention appropriate to the specific conditions of the small-scale farmers in the Harar milkshed.

CHAPTER 8

GENERAL DISCUSSION AND CONCLUSIONS

8.1 CHARACTERIZATION OF THE DAIRY PRODUCTION SYSTEMS IN THE HARAR MILKSHED

From the cluster analyses, seven clusters of dairy production sub-systems, four from the rural and three from the urban areas, were identified in the Harar milkshed. The clusters in the rural areas are: Traditional intensive dairy (TDS), Semi-intensive dairy (SIDS), Agro-pastoralist dairy and Agro-pastoralist dairy system (EAPD). The first two systems (TDS and SIDS) are prevailing in the highlands whereas the remaining two (APDS and EAPD) are found in the lowland areas. The three clusters identified in the urban areas include urban resource poor farms (URPD), urban intensive dairy system (UIDS) and specialised peri-urban dairy (SPUD).

The survey has also indicated that there are two main crop-livestock integrated dairy production systems in the rural areas of the Harar milkshed. In the highlands, where rainfall is less limiting to crop production, a crop-livestock system is dominant while in the lowlands, where rainfall is limiting for crop production and livestock production is more important a livestock-crop farming system is dominant. In the highlands, where the crop-livestock system is a dominant feature, it is common practice to keep cattle and small ruminants along with crop farming. In the lowlands however, livestock-crop is the dominant system and the livestock take a more diversified mode of production, which even includes camel production. In either system, the level of milk production is low.

Camels and small ruminants are preferred by the farmers in the lowlands because of their adaptability to this environment: efficient utilisation of the available plant material and as a risk minimisation strategy, particularly during drought situations that occur frequently in these areas. In addition, camels provide a number of useful products including milk, meat, transport, cash, in some places draught power and other social values to the owners. Furthermore, in the Harar milkshed, camel milk also plays an important role in complementing cattle milk, especially during the dry season when milk from cattle is in short supply. Camel milk provides considerable benefits to the owners by improving household nutrition and by generating additional income from the sale of surpluses. However, camel milk has a problem that limits its diversified use by the owners. Camel milk cannot be processed through traditional methods to obtain butter or ghee that would increase its shelf life and make it possible to obtain better material and economic benefit by the users. This requires immediate attention so as to promote a wider and more practical use of camel milk and enable the farmers to enjoy better benefits from camel milk.

There is an increasing shift towards the intensification of dairy operations through the use of crop residues and thinnings from crops, particularly sorghum with cut-and-carry feeding systems and keeping unimproved local cattle on the ever decreasing land area available for agriculture. The intensification of urban and peri-urban dairy production is based on purchased feedstuffs, mainly industrial brewery by-products, and conserved hay in stall-feeding systems, as well as the keeping of upgraded crossbred cattle based on superior Holsteins cattle were the main features of urban dairy farms of the area.

In the rural highlands of the Harar milkshed where land sizes are too small and thus the land size is a constraint, farmers are forced to intensify their cattle management by applying cut-and-carry systems. In some areas, particularly in the lowlands (e.g. Anood, Awsharif and Berkaley FAS), where the land holdings are relatively larger, farmers are still practising extensive grazing. However, due to the continued subdivision of the land inherited by the successive generations, these farmers might also be forced to adopt more intensive cattle management practices. This trend is now being reflected in the higher number of farmers practising zero-grazing in this study, compared to the practices some 10 to 20 years ago, as reported by the farmers in the area. It was noticed that in the highlands, the communal grazing lands which were used for cattle rearing in the past are now under crop cultivation, leaving little or no grazing land for cattle. This affects livestock production in general and milk production in particular. Similarly, the lowlands which were known to be pastoral areas, have now turned to settled agriculture and progressively more grazing land is being used for crop farming. Thus, future planning of dairy development and other livestock technology delivery efforts, should keep these strong needs in sight. It is unclear, however, what the long-term competitiveness of these different production systems will be. With current feed and land constraints prevailing in the highlands, the only option for livestock production is through application of more intensive practices. The strategies for developing the feed resources may include growing various improved forage crops in such a way that it will be less competitive to the crops, such as planting fodder crops on the sides of croplands, backyards, in the galleys and road sides.

In the lowlands, however, appropriate range management schemes need to be developed. This basically requires an understanding of the state of affairs of the current condition of the range in order to develop appropriate interventions. The main focus in addressing the lowland production systems with a view to promote dairy production must primarily consider marketing problems followed by solving water constraints. Given these serious constraints of the production systems any improvement in these areas, for example, to generate economic development to the beneficiaries, could swing the advantage more towards milk production.

Currently the agricultural extension services give more attention to crops than to livestock farming. In most cases the livestock extension service is almost non-existent, not only at regional level but at national level as well. Similar findings have been forwarded by Abay *et al.,* (1989) and Tegegne & Alemu (1989). In fact, these authors have identified the major limitations and constraints to the livestock sector in general and forwarded some important points worth of consideration in the future development of the sector. Most of the points raised in their reports are still valid and reflects well the findings of the current study.

The Ethiopian government has put food self-sufficiency as a priority with rural based industrialisation as strategy. In order to effectively materialise the envisaged plan and to bring forth changes in crop farming a number of government, non-government and private agencies are providing support and services to these farmers. Some of the support services available for increasing crop production and those required for the improvement and development of the livestock sector are presented in Table 8.1.

The list of support and services available to increase crop production (Table 8.1) are provided to the crop farmer in various forms. However, the livestock sector has not been given its fair share and as such, the major constraints to improve the sector have not been adequately addressed. There are still much to consider especially regarding policy and socio-economic issues, institutional, technical and non-technical matters associated with livestock development, which are due for consideration in light of the prevailing policy and economic environment, at national level.

Table 8.1 Comparison between input and services available and those required to improve crop and livestock production in the Harar milkshed

Input and services available for improvement of crop production	Input and services required to improve livestock production
Crops	Livestock
Land	Land
Improved seed	Animal genetic improvement
Fertilizers	Feed resources
Pesticides	Veterinary services
Preservation and storage facilities for grain	Preservation and storage of semen
Processing facilities for grains	Processing facilities for milk products
Marketing for grains	Marketing facilities for milk delivery

Source: After Tegegne & Alemu (1998)

8.2 THE ROLE OF RUMINANTS IN THE FARMING SYSTEMS OF THE HARAR MILKSHED

Results from this study indicated that households in the rural areas of the Harar milkshed engaged in several activities in response to their physical conditions, resource endowment and socio-economic needs. Cropping is the primary activity of farmers to produce food for home consumption and sale. The principal determinants for crop production in the Harar milkshed are: soil quality, rainfall and related climatic factors, availability of water sources for irrigation and altitude. The rainfall pattern also varies between different locations of farmers associations' (FAS) and within locations between the years in the areas surveyed. This large variability is common for the rural areas of the Harar milkshed and results in different cropping systems and land use. The 10 FAS were selected on the basis of a set of criteria, mainly land size and cropping systems in use. Galmashira, Deretayara and

Awberkaley FAS are in the highlands while Kile, Ifadin, Anood, Awsharif and Barkaley FAS are in the lowlands. Although affected by erosion, not all the top soils have been removed in most cases. *Chat* is the predominantly grown cash crop in the highlands and groundnut is cultivated in the lowlands. There are very little forests left. In almost all areas surveyed farmers grow sorghum and maize as food crops for subsistence.

The rural households can supplement their income from crops by keeping ruminants or through non-agriculture or off-farm work. Engagement in a variety of farming and off-farm activities is a strategy of rural poor households. Complementary activities may improve the income and employment and hence reduce the economic risks of the rural households who are strongly dependent on agriculture for a livelihood. Similar to other parts of Ethiopia, ruminants are basically kept by farmers to increase and add value of non-marketable crop residues of little value and native grass by converting them into products that are both tangible (live weight, milk, manure and draught power) and intangible (insurance/risk diversification and financing). Cattle are the preferred ruminants as they fetch a high cash price at sales. The rural households who lack the capital to purchase cattle can obtain animals through sharing arrangements from the farmers who have cattle. Such systems are common in the Ifadin FAS.

Milk production from the cattle is a very important product and the rural households believe that milk is the primary purpose for raising cattle. In most places the majority of rural households rank milk production much higher than other attributes of cattle raising. Milk is therefore the key to livestock husbandry, providing for household needs in various forms, including supplementation of income in the rural areas of the Harar milkshed. In the rural areas, dairy production is entirely based on local cattle breeds and traditional management systems. These systems are characterised as low input and low output in terms of animal performance, which greatly suffer from seasonal shortages of forage. This has a large influence on general animal production, particularly milk production. However, even when forage is in short supply the local cows can survive and produce some milk for their calves and for the household by mobilising their body reserves. The milk yield of local cows was estimated at 2 to 3 liter per cow per day.

Milk was found to be the major reason for raising cattle and because particularly in the lowlands, milk sales may constitute the major sources of household income, there are at least two aspects that need attention. These are the problems associated with milk marketing and processing. Households in far away places (>14 km from the market site in urban areas) do not have access to markets and in most cases producers in these areas process their milk using traditional methods which are less efficient. Even those households who are a bit closer to the market and who wish to deliver milk to the market, are not able to sell their milk themselves. They are forced to make use of the available channels to deliver milk to the market, i.e. they have to rely on the traditional milk association groups or deliver their milk through retailers (milk women) to the consumers. These systems seem to lack a sense of security for the producers, such that they are always at risk of losing the benefit they deserve owing to the possibility of spoilage of milk and the extremely high costs involved in transportation.

Rural households find that manure is an important product for crop farming and even better in certain aspects than inorganic fertilizer particularly when cash crops like *chat* and coffee are considered. Unlike in many other parts of the country, farmers in the Harar milkshed have long recognized the benefits of manure and this has been used widely in crop farming as organic fertilizer in almost all the areas surveyed. However, the problems related to manure utilization were identified as a lack of adequate amounts of manure for the crop farm and means of transportation. This may be because of the fact that the amount applied is very large, almost half a ton is required per ha per year and that makes it difficult for small-scale farmers to apply satisfactory levels of manure. In the rural households' perception, particularly in the highland where *chat* is the predominant cash crop, manure production is as relevant to them as the production of the progeny or the milk by cattle. On that basis one would expect that income from the manure should be as high as the income from live weight gains or milk. Thus, the income analysis needs to be planned so as to clearly understand the value of various functions or products from cattle under different production systems and environmental settings. However, it has been noted that manure has a high economic value as without it, farmers need to purchase more expensive organic fertilizers to secure crop production. In rural areas, manure is not traded. This indicates that rural households value manure for their own use and also that the amounts produced are not in excess of what is needed by themselves.

The envisaged research and development programmes should not only include meat and milk production, but also include other aspects of livestock rearing and include all the benefits of livestock keeping. Up to now, research aimed at improving livestock keeping in general, focused on physical production whereas the additional roles of livestock, such as being a living savings account or bank on hooves and an insurance against unforeseen events particularly droughts, are only described in qualitative terms.

8.3 URBAN DAIRY PRODUCTION SYSTEMS IN THE HARAR MILKSHED

It is concluded from the results of the current study that the urban dairies play an important role mitigating substantially the growing demand for milk from urban dealers in larger towns and cities in Ethiopia.

The urban dairy component of the Harar milkshed is also known to provide a number of benefits to urban dealers. The urban dairies, being more labour intensive, support a substantial employment force in activity in the Harar milkshed as well as in other regions of Ethiopia. It also tends to support crop farming by providing manure to the rural areas in exchange for crop residues. These benefits could be expanded, especially if the prevailing transport problems are minimised. However, milk production and reproductive performance of dairy farms were far from satisfactory. A comparison between the three clusters showed that, for the majority of production parameters, Clusters 5 and 6 outweighed those urban dairy farms in Cluster 7. The quantity and quality of the dairy rations was better in Clusters 5 and 6 compared to Cluster 7 farms. Except for housing and housing management (hygiene), almost all herd management practices, including feeding, were better in farms from Clusters 5 and 6 than in those from farms in Cluster 7. However, housing and house management practices were better in Cluster 7, which subsequently resulted in much lower disease incidents than in farms from Clusters 5 and 6.

Low productivity observed on urban dairy farms may due to the poor management levels practiced by these dairy farms. In addition, the urban dairy farms were noted to have been encountering a number of challenges that include absence of reliable sources for obtaining improved genotypes and related animal breeding problems, as well as required level of feed input. Improved preventive and curative veterinary services and marketing facilities are important constraints. Dairy cooperative associations (self-help schemes) were also not in place, which would have enabled these dairy farms to pool their capital, skills and efforts and partly solve the above mentioned problems by themselves. The establishment of farmers associations facilitate the delivery of extension and veterinary services to farmers.

8.4 OPTIONS AND CONSTRAINTS FOR IMPROVING DAIRY PRODUCTION AND PRODUCTIVITY IN THE HARAR MILKSHED

In marginal areas, livestock and agriculture in general, are usually described in terms of low production and productivity. This applies to the rural lowland areas of the Harar milkshed where livestock are apparently inadequately exploited and managed. The pressure to feed the growing urban population and the fact that there is little scope for the expansion of these farming operations in the existing agricultural areas, particularly in the highlands, has forced the rural households to pursue the route of intensifying farming activities on the existing agricultural areas.

The results from the current study lead to the conclusion that socio-economic and technical constraints form a great hindrance for increasing milk production, particularly in resource poor areas. Anderson (1992) mentioned that low uptake of 'improved' technologies is related to the fact that, within the limited resources and opportunities open to resource poor farmers, new technologies are not more profitable than the existing practices. In addition the new technologies are often too risky and are impossible to implement in time because of labour shortages and the lack of supporting infrastructures. Ellis (1988) distinguished two approaches with regard to technical change in agriculture: the improvement approach and the transformation approach. The improvement approach means that if farmers are technically inefficient, farmer education and extensions within the constraints of existing technology, need dramatic changes in technology.

Chamber *et al.* (1989) analysed examples from efforts to introduce new technologies to the diverse risk-prone areas in the tropics. The present study also falls into this category. Chamber *et al.* (1989) showed that farmers in such areas are continuously experimenting, adapting and innovating to survive. They classify, choose, improvise and adapt technologies depending on their circumstances. On this basis, Chamber *et al.* (1989) concluded that what the farmers need is not so much a standard package of technologies or practices but more a basket of choices. Petheran (1992) and Fujisaka (1994) also indicated that before they adopt an innovation, farmers need to see that it works better than their present practices. Differences in management practices of individual farmers do exist and they can act as catalysts for changes in the system (De Jong, 1996). Preston & Leng (1997) claimed that in most developing countries, livestock production plays a fundamental and often catalytic role in the development process. However, in the marginal area of the Harar milkshed, changes in the use of ruminants have always been followed by the changes in the overall development of the area. It is expected that in future changes in livestock rearing will continue to depend on changes in crop production and in the non-agricultural sector.

In the Harar milkshed, increased milk production in the herd is the most important aim of rearing ruminants. Efforts to improve milk production must be directed both to the breeding and management of dairy animals, mainly cows. Technically this may be done through disease control, mainly mastitis and reproductive diseases, improvement of the feeds, especially the quality (energy and calcium) of feeds for pregnant and lactating cows, the use of which involves cash input. The resulting increase in milk production might be unpredictable, therefore its acceptance by dairy farmers is uncertain. However, preliminary trials, followed with a practical field demonstration to the farmers, may be required before providing any extension packages to the producers, especially if a new technology is desired to be accepted and adopted by the farmers.

The inability of farmers to adopt and finance the cost of new technologies is a common problem in many parts of Sub-Sahara Africa for crop production, as well as for livestock production (Devendra *et al.*, 2000). Proposed new technologies are often based on the idea that efficient production requires that animals should be fed to meet certain production targets. However, the concept of feeding according to standards loses much of its value in low input systems (Schiere & de Wit, 1993). Feeding according to standards assumes a demand driven production system, but such systems are only feasible in appropriate physical and economic environments (consumers with large purchasing power) that allows farmers to use high quality input (including high quality forage and or concentrates). This could be practical for urban dairy farms because it seems that their purchase power is better than the rural areas especially households in Cluster 7 (specialised urban dairy), as the owners are engaged in a number of businesses other than agriculture alone. Feeding standards can hardly be practically applied by the resource poor farmers in the urban dairy systems, simply because the animal production of resource poor farmers operating in a less favourable environment is best characterised as utility maximizers rather than production maximisers. Their poor economic capacity and lack of resources force them to avoid the economic risks of new technologies as much as possible, unless these technologies are appropriate under their specific resource poor farmer conditions.

8.5 EVALUATION OF THE METHODOLOGY USED IN THE STUDY

8.5.1 Data collection analysis

The objectives set in Chapter 1 had to be transformed into research questions. Data to answer the questions were gathered by interviewing rural and urban households and key informants, field observations and monitoring urban dairy farms that involved measurements and laboratory analyses. Studying primary and secondary data from relevant literature were also considered. It should also be noted that the study was presumed to be part of the national program envisaged to characterise dairy systems and thus, followed the "Characterisation of dairy systems" project in which the farming system analysis approach (Rey *et al.,* 1993) was used. The study started with a "Reconnaissance Survey" covering the rural as well as the urban dairy systems in the Harar milkshed. This was followed by monitoring activities on some urban dairy farms. Farm households, which were considered to be representative for the recommendation domain, were selected following the criteria mentioned in Chapter 2.

It was found that reliable information concerning rural farm household possessions could not be obtained in the quick survey. Farmers were reluctant to give this information to outsiders unless they were provided with incentives such as cattle drugs or entertainment, with *chat* including food in certain situations. They also expressed their concern about the time they were spending on the interview and requested implicitly commensurate material benefits. It was only after a more intensive survey, in which the investigator stayed in the village, entertaining the farmers holding the traditional "Bercha" ceremony where enjoying chewing *chat* is the main feature, that it was possible to find out that some respondents in some farmers association like Anood, Awsharif and Ifadin FAS possessed larger numbers of livestock and land holdings than originally stated. Apparently correct information on land holding became available only very gradually during a subsequent intensive farm household survey and often as a result of casual remarks made by the farmers or other members of the household while discussing other subjects. It was noticed very often that farmers tended to overestimate or underestimate the size of their land holdings. Land and animals may be owned or shared and the area of land farmed may vary because farmers gain access to new plots or animals, or abandon plots or dispose of animals they have been keeping. Thus, obtaining accurate information on the physical resource base of respondent farmers was a complicated and time-consuming process.

Almost similar problems were faced in the urban dairy areas. Urban households were reluctant to allow the investigator to enter the farm unless he was accompanied by workers from the Agricultural Bureau of the region. Some of the households were also not willing to allow the identification of their animals, weighing the animals and the amount of feed supplied. Their main reason was that the study takes or wastes their time with no apparent benefit to the farm *per se*. According to these farmers, the dairy farms are already tired of interrogation and the drawing of various laboratory samples, which was done at different times by different institutions with virtually no benefit and virtually no feedback. Therefore, to ensure the success of this kind of study it should be born in mind that it is imperative that these problems are addressed before such a study is planned. Finally, to run such a systems analysis research, it is felt that a multidisciplinary approach is required to measure the interaction between various disciplines, which helps reaching an understanding about the complexity of the farming and household activities and the possible implications of interventions in the farming systems. For example, a study of crop farming practices, soil and water conservation practices, the income from crop and livestock and the contributions of each component activity to the farm household should be evaluated by experts in the corresponding disciplines. This allows the farm household to be viewed in a more holistically and sound manner. As a result, the outcome of such studies will be much more helpful, not only for animal production disciplines, but also in other related disciplines, particularly in the planning of development-oriented agricultural projects for the area. In addition, it has to be noted that a relatively longer time is actually required, compared to the time spend for this study, to conduct such a comprehensive research project in a more exhaustive manner.

8.6 RECOMMENDATIONS

In conclusion, the recommendations from this study are made at three levels, namely the policy, research and extension levels.

8.6.1 At the policy level

The livestock sector should receive its fair share in terms of input and services required to improve and promote the livestock sector for better production in the Harar milkshed. The following aspects require urgent consideration:

- Regulate the urban and peri-urban dairy farming operation.
- Regulate the use of natural pastures around Harar (particularly in Kersa).
- Promote the removal of manure and its productive use for among others biogas and crop production.
- Provide a minimum veterinary herd health management package to prevent the risk of zoonotic diseases (brucelosis, tuberculosis, etc.).
- Promote the access to markets and the marketing of the milk from rural areas, supply support to the existing milk association groups and recognise the role of women.
- Promote the establishment of the dairy associations in urban areas to facilitate the delivery of services and assistance.

8.6.2 At the research level

During this study, a number of aspects were identified for future research projects. These projects should have a multidisciplinary approach involving socio-economic, crop and livestock production aspects. The following short list of aspects require further research:

- The role of cattle, particularly the socio-economic aspects on the rural households involved in agriculture.
- Evaluate the potential feed sources available in the area (industrial brewery waste and mineral sources such as different type of soils, rocks and water from wells and ponds) in terms of their production, conservation and utilisation.
- An evaluation of the current condition of the rangelands and various alternatives for improving the utilisation methods for sustainable livestock production and environmental protection.
- An evaluation of the contribution of crop residues and thinnings for animal feeding and its effects on soil fertility.
- Traditional milk technologies should be evaluated, particularly improving the traditional equipment and possibly looking into the methods that would allow camel milk to churn.
- Development of management systems to improve animal feeding and housing management, particularly calf rearing and nutrition of the producing cows.
- Conduct cultivar trials to improve yield/ha but also improve other uses such as plant residue yields.

8.6.3 At the extension level

Efforts by departmental extension staff should be focused and strive:

- To promote the adoption of appropriate (locally adapted) technologies related to all aspects of dairy production.
- To provide a veterinary health care package aiming at improving animal production and protecting or safeguarding public health.
- To establish an AI center and provide AI services aiming at improving the genetic profile of the animals adapted to the local management condition.
- To promote farmer participation in the identification and implementation of programs aiming at improving dairy production in the Harar milkshed.

- To promote mixed cropping (in strips) that includes fodder plants such as sorghums and babala.
- To establish and develop communication channels between farmers, policy makers, extension workers and researchers.

Ideally, the principles of Farming System Research and Extension (FSR-E) should be incorporated in all the efforts suggested above.

CHAPTER 9

COMPILATION OF PHOTOGRAPHS

Plate 1 One of several large gates (*Badro Beree* – to the west) giving access to the walled city of Harar

Plate 2 Cattle grazing outside the walls of the city of Harar

Plate 3 **Camels (*Camelus dromedarius*) browsing natural rangeland along a road leading to Harar**

Plate 4 **Chat (*Cahta edulis*) inter-cropped with maize (*Zea maize*) close to Harar (highland)**

Plate 5 **Inter-cropping of sorghum (*Sorghum vulgare*) and groundnuts (*Arachis hypogaea*) with two tethered cattle close to Bisidimo (lowland)**

Plate 6 **Elephant grass (*Pennisetum purpureum*) irrigated with effluent water obtained from the beer brewery in Harar**

Plate 7 Freshly cut green grass used in a cut-and-carry feeding system in Harar

Plate 8 A donkey used to carry wet brewers grain along a small alley to a dairy farm in Harar

Plate 9 **Wet brewery grain retrieved by hand from storage in a ground pit before being fed to dairy cows in Harar**

Plate 10 **Wet brewery grain stored in a cement-lined pit on a dairy farm in Harar**

Plate 11 Dairy cows grazing in the backyard of an orphanage in Harar

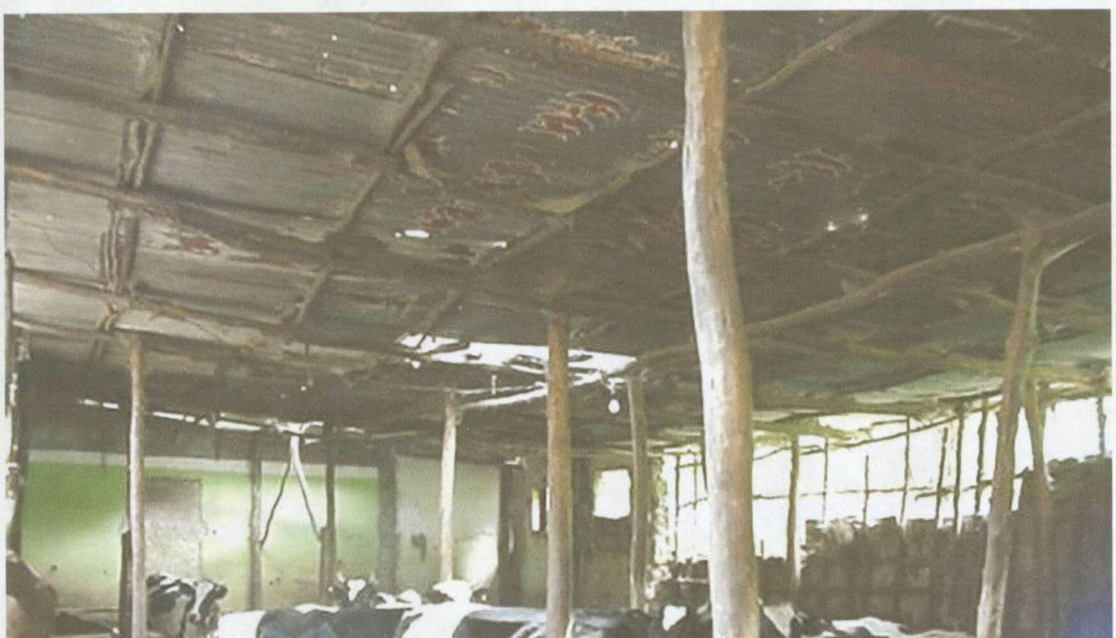


Plate 12 Dairy cows in a parlour in the backyard of a business premise in Harar

Plate 13 Dairy cows in a parlour - an example of improved housing on the outskirts of Harar

Plate 14 Dairy cows in a mud-walled housing with a stone paved floor in Harar

Plate 15 Partial view of a milk marketing centre on the Babile road – the milk being collected and awaiting transportation to Harar

Plate 16 Milk market women at a Babile milk marketing centre

Plate 17 Milk loaded on a vehicle and ready to be transported to Harar

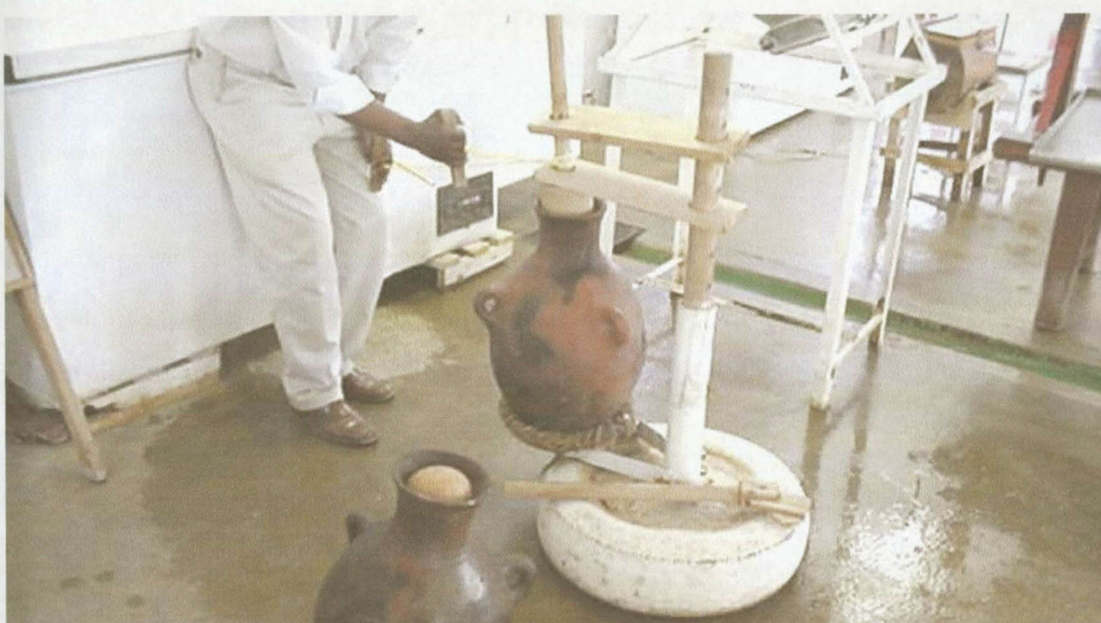


Plate 18 An improved churn for making butter

ABSTRACT

CERTAIN ASPECTS OF THE DAIRY SYSTEMS IN THE HARAR MILKSHED, EASTERN ETHIOPIA

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A study, comprising a survey and a monitoring component, was undertaken to characterize and identify the major constraints for dairy systems in the Harar milkshed, eastern Ethiopia. Important implications from the findings can be divided in five key areas, namely: intensification of smallholder systems; constraints to dairy production; access to services; role and importance of urban dairies; and identification of target groups. The results have showed that the majority of rural households are agricultural (91% of the surveyed households) and many (89%) of the agricultural households' practices dairy farming. Rapid intensification of smallholder dairy production is occurring in the Harar milkshed as a result of the shrinking land due to continuous population pressure. Over the past two decades the farming systems have shifted increasingly to increased use of stall-feeding and planting of food crops on land previously used as natural pasture and thus livestock production has to rely increasingly less on grazing. There is an increasing shift towards intensification of dairy through the use of crop-residues and thinnings from crops, particularly sorghum, with cut-and-carry feeding systems and the keeping of unimproved local cattle on the ever decreasing land available for agriculture. However, there are large differences in levels of intensification in the area depending on agro-climatic factors and access to the market. The main implication is that while

improved technologies for sustainable intensification are required they cannot be applied uniformly throughout the Harar milkshed. Blanket recommendations for intensive production strategies should be avoided. A difficult challenge may be to assist the appropriate intensification of farming practices especially in those outlying areas where many resource poor farmers are found. These areas do not have a high agro-ecological potential due to moisture constraints, soil and rangeland degradation and poor access to markets, yet need to improve productivity from dairy activities.

Households that were surveyed in the rural areas fell into four clusters based on the results of the cluster analysis. The majority of the rural households surveyed fell into Cluster 1, named the Traditional Intensive Dairy (TID) farmers (3%) and Cluster 2, named the Traditional Semi-intensive Dairy (TSID) (40%). Households in Cluster 3, named the Traditional Extensive Dairy based on Extensive Agro-pastoral systems (TAD) and Cluster 4, named the Traditional Extensive Agro-pastoral Dairy (TEAD) constituted about 7% and 23% respectively of the rural households surveyed. Households in Clusters 1 and 2 had smaller areas of land and smaller cattle herd sized compared to households in Cluster 3 and 4. Households in Cluster 1 did not have grazing and had smaller crop lands than the other three clusters. Despite the small crop areas, households in Cluster 1 had larger quantities of crop residues than Clusters 3 and 4. This larger quantity of crop residues produced in Cluster 1 is attributed mainly to the higher amount of rainfall received compared to the other two clusters.

Two major feed resources identified in the rural areas were the thinnings and weeds that are normally obtained from sorghum and maize crops, starting from early stages (at knee height) until harvest. No hay making practices were detected in the rural areas surveyed.

It was noted that traditionally milking, processing, marketing and delivery of milk are the affairs of women in the rural area of the Harar milkshed. The survey showed that milk equipment was generally washed and some special herbs were used as local disinfectants. These herbs include "Baka Arkate" *"Lantana Kamara"* which is available almost everywhere in the area surveyed. The milk equipment is further smoked with the various plants in order to clean the micro-organisms that spoil milk. Some farmers boil the night milk to help them in preserving milk during marketing.

Three milk delivery channels were identified in the Harar milkshed. Milk delivery association groups were dominant, followed by delivery of own milk or direct delivery and individual collectors/milk women traders in the Harar milkshed.

Milk from cattle and camel are used by the urban population in Harar. However, cattle milk is preferred to camel milk by the majority of the urban population. Babile (Erer and Kore) and Bisidimo were found to be potentially important sources of both camel and cattle milk to supply milk to Harar. A total of 375 and 685 liters of cattle and camel milk were supplied daily from Babile and the corresponding volumes for Bisidimo were 840 and 523 liters per day. Fluctuations in daily milk supply however, were quite apparent over different months of the year. A number of constraints were mentioned by the farmers concerning milk delivery and marketing situations in the Harar milkshed. An overwhelming majority (75%) of the farmers interviewed ranked the transportation problem first, followed by the risk involved (12%) and the remaining (16%) reflected on the lower price obtained for one liter of milk. Milk processing equipment and the processing methods used are quite traditional requiring improvement in order to enhance the productivity and efficiency of dairying in both rural and urban areas of the Harar milkshed.

Considering the urban dairies, results from the survey indicated that the majority of the households are none-agriculturists (84%) and are engaged in other business and regard the dairy as a sideline business. Intensification of dairying through the use of purchased feedstuffs, mainly industrial brewery by-products and conserved hay in a stall feeding system and keeping Holstein upgraded dairy cattle breeds are the main features of the urban dairies of the area.

The cluster analysis from the 50 urban households surveyed showed that there are three dairy production sub-systems that can be identified in the urban sector of the Harar milkshed, designated as Clusters 5, 6 and 7. Farmers in the urban area falling in Cluster 5 (URP – Urban Resource Poor) have a very small land size (0.3 ha) and no grazing but they buy a little fodder (less than Birr100/year). The second largest group falling in Cluster 6 (URMDS – Urban Medium Resource Dairy System) is composed of farmers with a slightly larger (n = 11) herd size, but they purchase more fodder and other feedstuffs. The last group of farms in Cluster 7 (SPUD) is distinguished primarily by a larger (4 ha) land size and 98% more fodder is purchased than for Cluster 5. Farm/household resources, such as labour, may be critical for intensification of dairy farming where dairy farming requires labour not only for a cut-and-carry feeding system, but for the overall management activities such as herding, cattle housing, feed and other input.

Eleven different feed types were identified during the survey in the urban dairy production system. Grass hay and the industrial brewery waste were the commonest feed types used in the urban dairy production system of the Harar milkshed. Hay is conserved and stored in a hay barn, but in a loose form. The industry brewery waste was successfully conserved in non-cemented silos or pits in the ground.

The chemical composition of the feedstuffs showed that there are diverse feed resources available in terms of their chemical composition and digestibility in the urban dairy production system. Most of the basal diets in the urban dairy production system are of fibrous nature, including sorghum stover and grass hay and these feedstuffs are low in protein content (less than 7%) which makes it difficult to promote rumen function. Hence, non-conventional feeds, notably industrial brewery waste and local brewery waste are potential feed resources to supplement low quality feeds in the Harar milkshed.

The majority (50%) of the urban dairy farms used bucket feeding for calf rearing. The remaining half of the farms were using suckling for calf rearing as well as milk letdown initiation in different sequences in relation to milking. No farm was observed using udder washing for milk letdown. Most used a milk ration during milking. The total amount of milk provided to the calves was 430 liter and age at weaning was about 129 days on average. However, there were differences among the cluster groups of the urban dairy farms.

All the dairy farms housed their crossbred cows in barns with roofed shelter, equipped with a feeding trough. About 54% of the barns for dairy cows were cleaned once a day while the remaining were cleaned either twice or even three times a day. The majority of the farms were very crowded and the cows were not separated by age and production. In urban dairy farms more than 60% of the manure produced was not used and wasted, 11% used it as fuel, 28% sold it as manure for crop farmers in the rural areas and about 1% used it for biogas production. The main constraint resulting in manure accumulation on the urban dairy farms appears to be the lack of adequate disposal. This tends to limit the use of manure utilization and consequently causes environmental problems threatening the prospects of dairy production in urban areas.

The overall mean annual disease incidence was 80% (47% for reproductive diseases and about 33% for other conditions). Reproductive problems (47%) and mastitis (18%) occurred most frequent. Placental retention and abortion were among the major reproductive problems representing about 69% of the clinical cases reported. Other clinical cases included digestive and respiratory disorders with an occurrence of about 8%.

Important threats to productivity in the urban and peri-urban dairies may be the constraints posed by irregular calving distribution, irregular milk production during the year and lack of strategic feeding systems. Dairy rations were deficient in both quantity and quality to meet the nutritional requirement for dairy herd. The ration was particularly deficient in energy and calcium. These deficiencies were much larger in farms with large herds than for medium and small herd sizes.

Reproductive performance of cows deviated negatively from the target values and was larger in farms of larger herd size compared to medium and small herds. Lower body weight and poor body condition scores before and after calving were found to be important in management of urban dairy farms influencing the productivity of the dairy farms in the Harar milkshed.

Reproductive and breeding problems were also identified as important problems in the urban and peri-urban dairy production systems. Although the artificial insemination (AI) service is used by a relatively large group of the farms, frequent interruption of the service seems to have forced the farmers to resort to use bulls of unknown pedigree. The access to AI services for dairy operation in the urban area is mixed with apparently successful private entry into veterinary services, but no attempt is made so far in the private provision of AI services. However, these services are used mostly by the large and advanced dairy farmers in the urban areas.

The survey highlighted the existence of an enormous supply-demand variance in milk products for Harar city, which indicates that potentially there exists good opportunities for development of the urban dairy sector in the Harar milkshed. Large-scale dairy farms and small urban dairy farms have the potential to minimize milk shortages in Harar.

Constraints to increase dairy productivity revolve around the inadequate and seasonal nature of feed sources. Solutions to these problems will have to keep in mind the limited access to opportunities outlined above in the Harar milkshed. The use of planted grass fodder for stall-feeding may be limited in the intensive areas where land rather than labour is the limiting factor. Access to markets may be considered as a major constraint, particularly for those farmers' associations located far from the milk market sites. Improvement in milk processing techniques could be a good prospect particularly for the places far from marketing centers. Urban and peri-urban dairy production systems are important in supplying milk to Harar. One of the threats to productivity in the urban and peri-urban dairies may be the constraints posed by reproductive disorders, diseases and breeding problems.

A cluster analysis indicated that more than half of the rural dairy farms in the Harar milkshed are resource poor farmers with small land holdings and usually located far from market sites in the urban areas. Improving the sustained productivity of dairy farms and profitability of the rural dairy farms and households will be a key to success in rural development, poverty reduction and environmental protection in the Harar milkshed. However, unless serious attention is given to improved and adequate feed sources and feeding programmes, much of the other high priority needs will not reach the required impact if applied.

OPSOMMING

SEKERE ASPEKTE VAN DIE MELKERYSTELSELS IN DIE MELKVOORSIENINGSGEBIED VAN HARAR, OOSTELIKE ETHIOPIË

deur

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'n Studie bestaande uit twee komponente, naamlik 'n opname en monitering van melkerye, is uitgevoer om die melkvoorsieningsgebied van Harar, oostelike Ethiopië te karakteriseer en die belangrikste knelpunte te identifiseer. Die belangrikste implikasies van die bevindinge kan in vyf sleutel areas verdeel word, naamlik: intensifisering van kleinskaalse melkerye; beperkings op melkproduksie; toegang tot dienste; rol en belangrikheid van stedelike melkerye; en die identifisering van teikengroepe. Snelle intensifisering van kleinskaalse melkerye vind in die melkvoorsieningsgebied van Harar plaas as gevolg van die krimpende grondoppervlakte as gevolg van die menslike bevolking se toenemende behoeftes. Oor die afgelope twee dekades het die boerderystelsels toenemend verskuif na stalvoeding van diere en die aanplant van voedselgewasse vir mense op grond wat voorheen as natuurlike weiding deur vee benut is. Daar is egter groot variasie in die vlak van intensifisering in die gebied as gevolg van agro-klimatologiese faktore en toegang tot die mark. Die implikasie is dat terwyl daar 'n groot behoefte is aan volhoubare tegnologie vir intensifisering van produksie, kan dit egter nie eenvormig in die gebied toegepas word nie. Algemene aanbevelings betreffende intensiewe produksiestrategieë in die gebied moet liefs vermy word. 'n Groot uitdaging bestaan veral rondom bystandverlening met toepaslike intensifikasie aan die hulpbron-arm

boere in afgeleë gebiede. Die gebiede het nie 'n hoë agro-ekologiese potensiaal nie as gevolg van vogbeperkings, degradering van grond en natuurlike weidings en swak toegang tot markte, maar nogtans moet produktiwiteit van die melkerye verhoog word. Beperkings om produktiwiteit van die melkerye te verbeter is veral geleë in onvoldoende voerbronne en die seisoenale aard van die voedingsbronne. Oplossings vir hierdie probleme moet die beperkte toegang tot geleenthede in die melkvoorsieningsgebied van Harar in gedagte hou. Die aanwending van aangeplante grashooi vir stalvoeding mag beperk wees in die intensiewe gebiede waar grond eerder as arbeid die beperkende faktor is. Toegang tot markte is 'n groot beperking veral vir daardie boereverenigings wat ver van die markte geleë is. Verbetering van melkprosesseringstegnieke mag groot voordele inhou, veral vir die afgeleë gebiede. Stedelike en omstedelike produksiestelsels is belangrik in die voorsiening van melk aan Harar. Die aanwesigheid van siektes wat reproduksie aantas en ook teelprobleme hou egter 'n groot bedreiging vir die melkerye in. Alhoewel die kunsmatige inseminasie (KI) diens wel deur 'n relatief groot groep boere gebruik word, dwing aanhoudende probleme in die onderbreking van dienslewering vele boere om bulle van onbekende oorsprong te gebruik. Die toegang tot KI dienste vir melkerye is swak in die landelike gebiede. In die stedelike gebied is toetrede van private veeartsenydienste bespeur, maar geen privaat inisiatief bestaan ten opsigte van 'n KI diens nie. Hierdie veterinêre dienste word ook veral net deur die groot en gevorderde melkery in die stedelike opset gebruik. 'n Trosanalise het getoon dat meer as die helfte van die landelike melkerye in die melkvoorsieningsgebied van Harar hulpbronarm boere is met klein gronde en wat ook ver vanaf die mark in die stad geleë is. Verbetering van volhoubare produktiwiteit van melkerye en winsgewendheid van die landelike melkplase en huishoudings is die sleutel tot suksesvolle landelike ontwikkeling, verligting van armoede en beskerming van die omgewing in die melkvoorsieningsgebied van Harar. Indien ernstige aandag nie terselfdertyd aan voldoende voerbronne en voedingsprogramme gegee word nie, sal vele van die ander hoë prioriteitsbehoeftes nie die verlangde impak hê nie.

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