LIVESTOCK PRODUCTION SYSTEMS IN RELATION WITH FEED AVAILABILITY IN THE HIGHLANDS AND CENTRAL RIFT VALLEY OF ETHIOPIA

MSc. Thesis

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Haramaya University

LIVESTOCK PRODUCTION SYSTEMS IN RELATION WITH FEED AVAILABILITY IN THE HIGHLANDS AND CENTRAL RIFT VALLEY OF ETHIOPIA

A Thesis Submitted to the School of Animal and Range Sciences,
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By

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As Thesis research advisors, we hereby certify that we have read and evaluated this Thesis, prepared under our guidance, by Zewdie Wondatir, entitled ‘‘**Livestock Production Systems in Relation with Feed Availability in the Highlands and Central Rift Valley of Ethiopia**’’ and recommend that it be submitted as fulfilling the Thesis requirement.

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DEDICATION

I dedicate this thesis manuscript to my beloved mammy **Gezash Kibret**, who passed away by leaving her eternal reminiscence to me when I was about to join Haramaya University.

STATEMENT OF THE AUTHOR

First, I declare that this thesis is my genuine work and that all sources of materials used for this thesis have been duly acknowledged. This thesis has been submitted in partial fulfillment of the requirements for MSc. degree at Haramaya University and is deposited at the University Library to be made available to borrowers under rules of the Library. I solemnly declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma, or certificate.

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Place: Haramaya University

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LIST OF ABBREVIATIONS

ADF	Acid Detergent Fiber
ADL	Acid Detergent Lignin
AI	Artificial Insemination
AOAC	Associations of Official Analytical Chemists
Ca	Calcium
cm	centimeter
CP	Crude Protein
CRV	Central Rift Valley
CSA	Central Statistical Agency
DCP	Digestible Crude Protein
DM	Dry Matter
EIAR	Ethiopian Institute of Agricultural Research
ETB	Ethiopian Birr
FAO	Food and Agriculture Organization of the United Nations
g	gram
GLM	General Linear Model
ha	hectare
HARC	Holetta Agricultural Research Center
IBC	Institute of Biodiversity Conservation
ILCA	International Livestock Center for Africa
ILRI	International Livestock Research Institute
IVDOMD	In vitro Digestible Organic Matter in the Dry matter
kg	kilogram
km	kilometer
masl	meters above sea level
ME	Metabolizable Energy
MJ	Mega Joule
mm	millimetre

MoA	Ministry of Agriculture
N	Nitrogen
NAIC	National Artificial Insemination Center
NLDP	National Livestock Development Project
NDF	Neutral Detergent Fiber
NGOs	Non Governmental Organizations
^{O}C	Degree Celsius
OM	Organic Matter
P	Phosphorous
PA	Peasant Association
SEDA	Selam Environmental Development Association
SNV	Netherlands Development Organization
t	ton
TLU	Tropical Livestock Unit
USD	United States Dollars

BIOGRAPHICAL SKETCH

The author was born in 1977 at Chole, East Arsi Zone, Oromia Region. He attended his elementary, junior and secondary school education at Sinkle, Chole and Arboye, respectively, in the same Zone. He then joined the then Awassa College of Agriculture in 1994/95 and graduated with a BSc degree in Animal Production and Rangeland Management. Thereafter he was employed in Afar Region Agriculture office at Zone Five Agriculture Department as a junior expert of hide and skin production and later as a team leader of livestock and fishery resource division and also coordinator of National Livestock Development Project (NLDP). The author served there for two and half years and was transferred to Alage Technical and Vocational Education Training College as an instructor and served for six months. In January 2002, he joined the then Ethiopian Agricultural Research Organization (now Ethiopian Institute of Agricultural Research) based at Holetta Research Center and worked as a researcher in dairy cattle and draught animals research program. He then joined the School of Graduate Studies of Harmaya University in October 2007 for his post-graduate studies in the field of Animal Production.

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LIVESTOCK PRODUCTION SYSTEMS IN RELATION WITH FEED AVAILABILITY IN THE HIGHLANDS AND CENTRAL RIFT VALLEY OF ETHIOPIA

ABSTRACT

A study was conducted to assess livestock production in relation with feed availability in the Highlands and Central Rift Valley of Ethiopia. Peri-urban dairy production system from Highland and mixed crop-livestock production system from Central Rift Valley were considered for the study. The Highland peri-urban study sites were Debre Birhan, Jimma and Sebeta while Ziway was considered from Central Rift Valley. The study was initiated with the objectives to gain insight in the temporal and spatial availability of feed and its quality to target interventions in feed production and management in relation to livestock development in two production systems of Ethiopia, to investigate major constraints of feed supply in the selected areas, to assess the performance of cattle in the selected areas and to develop advising strategies for livestock improvement. A reconnaissance survey was used to get the general picture of the study sites. Purposive sampling was employed to select target farms. Structured questionnaire, focused group discussions, secondary data sources and field observations were employed to generate data. A total of 60 farmers from Highland system (Debre Birhan=20, Jimma=20 and Sebeta=20) were selected for the study. The farms were further stratified into small and medium herd size. Similarly, a total of 60 livestock owners were selected from Ziway area. Samples of major feed resources were collected from both system and their chemical composition was determined. Data were analysed using descriptive statistics and General Linear Model of the SAS software. The result of the study indicated that both natural pastures and crop residues were the main basal diets in Central Rift Valley system while grass hay was the main basal diet in the Highland system. Among Highland system, farmers in Jimma and Sebeta do not have grazing and crop lands. On the other hand, farmers in the Central Rift Valley (around Ziway) and Debre Birhan possess crop and grazing lands. The major feed resources in Jimma and Sebeta were purchased hay and agro-industrial *by-products while crop residue and natural pasture grazing were among the common feed resources in Debre Birhan and Ziway. About 58 and 90% of the respondents face feed shortage during dry season in the Highlands and Central Rift Valley production system, respectively. About 50% of the respondents in Ziway area indicated feed shortage due to encroachment of crop farming into grazing lands. Among the Highland system, in Debre Birhan 60 and 40 % of the dairy farmers described that grazing lands are converted into croplands and expensive market price of concentrate feeds, respectively, as the main problems of feed supply. Seventy five percent of both small and medium herd size dairy farms at Jimma and Sebeta had feed problems in relation with the current escalating cost of feeds. More over 80 and 55% of the dairy farmers at Jimma and Sebeta, respectively indicated that commercial feeds are not available sufficiently in the market. Laboratory analysis of major feed resources indicated that hay had CP content of 6.1% and grazing pasture 7.2%. CP content of crop residues varied from 3.1 to 6.7%, which was below the minimum requirement of 7.0% for optimum microbial function. In addition, crop residues had lower digestibility (47%) and energy value ranges from 6.5-7.9 MJ/kg DM. NDF content of crop residues was above 65%. ADF content of crop residues varied from 48-62% and lignin values were varied from 10-17%. ME for commonly used energy supplements such as wheat bran and molasses was 13.2 and 12.5 MJ/kg DM, respectively. Among the protein supplements, brewery wet grains had slightly lower CP (27%) than cotton seed cake (42%) and noug seedcake (35%). Annual feed balance estimation revealed that the total estimated available feed supply in the Highland production system met 83% of the maintenance DM requirement of livestock per farm per year. In the same production system, the total estimated CP and ME were 40 and 10% surplus per year per farm. On the other hand, in the CRV (around Ziway), the total annual DM met only 66% of the total livestock requirement per annum per farm. In the same way, the total yearly available DCP and ME cover only 37% and 67% of the total livestock requirement per farm per annum, respectively. The estimated mean daily milk yield varied significantly ($P<0.001$) among the Highland sites. In Sebeta the estimated daily milk yield (9.7 kg) per cow was higher ($P<0.001$) than Jimma and Debre Birhan. The overall estimated daily milk yield from indigenous Arsi zebu cattle in Central Rift Valley (Ziway) was 1.5 kg per cow. The overall estimated mean lactation length of cows in the Highland production system was 296* *days and was not different ($P>0.05$) among sites. Estimated lactation length of 321 days in Central Rift Valley (around Ziway) was slightly longer. The overall estimated mean age of heifers at first service was 27.5 months and age at first calving was 36.8 months and differed ($P<0.001$) considerably among the study sites in the Highland production system. The overall estimated mean ages at first service and calving in the Central Rift Valley (Ziway) were longer (51 and 60 months, respectively). Assessment of market price of feeds and milk showed that in the Highland study sites noug seedcake had the highest price and varied from ETB 2.13 to 2.41 per kg feed. In Sebeta area the price of brewery wet grain was lowest (ETB 0.18 per kg feed). Brewery wet grain had the lowest price (ETB 0.02) per unit of metabolizable energy (ME) while noug seedcake had the highest (ETB 0.23). The price for locally processed products such as butter and Ayib was highest in the dry season in all study areas. Therefore, from the current study it was concluded that the quality of available basal roughage feeds is generally low and strategic supplementation of protein and energy rich feeds should be required. Alternative means of dry season feed production and supply should be in place with the involvement of all stakeholders and development actors. In relation with the rising market price of concentrate feeds, other optional feeds like brewery wet grains and non-conventional feed resources should be taken into consideration.*

1. INTRODUCTION

Ethiopia is believed to have the largest livestock population in Africa. The recent livestock population census (CSA, 2008) shows that Ethiopia has about 49.3 million heads of cattle, 25.0 million sheep, 21.9 million goats, 1.8 million horses, 5.4 million donkeys, 335 thousand mules, 760 thousand camels and 38.1 million poultry. This does not include livestock population of three zones of Afar and six zones of Somali regions.

Several authors have classified livestock production systems in Ethiopia using different ways. Most classifications are based on the criteria that include degree of integration of livestock with crop production, level of input and intensity of production, agro-ecology and market orientation. Accordingly, about five production systems have been defined; namely pastoral, agro-pastoral, mixed crop-livestock farming, intensive dairying and peri-urban dairying (MoA, 1997; Yoseph, 1999; Mohammed *et al*., 2004; Yitay, 2007). Across all production systems, the production of milk and milk products has vital place where 99% of the total milk production is contributed by cattle.

Ethiopia holds large potential for dairy development mainly due to its large livestock population, the favorable climate for improved high-yielding animal breeds, and the relatively disease-free environment (Winrock International, 1992; Halloway *et al*., 2000). In addition, the country enjoys diverse topographic and climatic conditions and hence milk production, at different levels, takes place across all agro-ecological zones. In the highlands milk is mainly produced on small scale mixed farmers while in the lowlands, pastoralist production systems are predominant. There are also intensive and commercial dairy farms in the country. The majority of cows kept are indigenous breeds, with a limited number of farmers keeping few crossbred grade dairy animals (Gebre-Wold *et al*., 2000).

However, despite large number of livestock resources in the country, its productivity is extremely low. The livestock sector in Ethiopia contributes 12 and 33% of the total and agricultural gross domestic product, respectively (Ayele *et al*., 2003). The per capita consumption of milk is estimated to be 19.2 kg/person/year, which is very low as compared to the average per capita consumption of Africa, 37.2 kg/person/year (FAO, 1998; FAO, 2000).

An increasing demand for dairy products in the country is, however, expected to induce rapid growth in the dairy sector. Factors contributing to this demand include the rapid population growth (estimated at 3% annually), increased urbanization and expected growth in incomes (Mohammed *et al*., 2004). The shift in national policy towards a more market-oriented economy will facilitate private entrepreneurs to respond to the increased demand through increased investment in dairy production and milk processing. While the response of the private sector to the increased demand for dairy is expected to be significant, the small-scale farms in the highlands hold most of the potential for dairy development. Currently, a number of smallholder and commercial dairy farms are emerging mainly in the urban and peri-urban areas of Addis Ababa (Felleke and Geda, 2001; Azage, 2003) and most regional towns and districts (Ike, 2002; Nigussie, 2006). According to Azage and Alemu (1998), there were 5167 dairy farms producing milk annually in the Addis Ababa milk shade.

In Ethiopia, annual milk production per cow is generally low due to reduced lactation length, extended calving interval, age at first calving and poor genetic makeup. One of the major problem to such low milk production is shortage of livestock feeds both in quantity and quality, especially during the dry season. Moreover, progressive decline of average farm sizes in response to rising human populations, encroachment of cropping land onto erstwhile grazing areas and onto less fertile and more easily erodible lands, and expansion of degraded lands which can no longer support either annual crops or pastures contributed to shortage of feed resources (Anderson, 1987; Alemayehu, 2005). Further poor grazing management (e.g. continuous overgrazing) contributed to shortage of feed resources as a result of replacement of productive and nutritious flora by unpalatable species (Ahmed, 2006). Feed supply from natural pasture fluctuates following seasonal dynamics of rainfall (Alemayehu, 1998; Solomon *et al*., 2008a). Furthermore, quality of native pasture is very low especially in dry season due to their low content of digestible energy and protein and high amount of fiber content. This is much worse for crop residues owing to their lower content of essential nutrients (protein, energy, minerals and vitamins) and lower digestibilities and intake (Seyoum and Zinash, 1988; Chenost and Sansoucy, 1991; Zinash *et al*., 1995). Despite, these problems, however, ruminants will continue to depend primarily on forages from natural pastures and crop residues.

Peri-urban dairy production systems have been emerged around cities and towns, which heavily rely on purchased fodder. The term peri-urban refers to the linkage and interaction between rural and urban areas and characterized by the production, processing and marketing of milk and milk products that are channeled to consumers in urban centers (Rey *et al*., 1993 as cited in Yoseph, 1999). Fonteh *et al*. (2005) also defined peri-urban as an area located at the outskirts of town (between approximately 5 and 10 km away from town). Further commercialization of dairy production takes place around cities and towns where the demand for milk and milk products is high (medium and large towns). However, the production system has been constrained by several factors of which in adequate year round feed supply (quantity and quality) is the focal point. Few research works have been carried out with regard to feed availability in relation with dairy animals in urban and peri-urban dairy farms (Yoseph *et al*., 2003a). Current and up-to-date baseline information is lacking in peri-urban areas on feed availability and quality under the prevailing situations. As a result, there is a need to investigate the feed demand and supply situation in the peri-urban areas with the aim to identify suitable strategies to provide adequate amounts and sufficient quality fodder to the dairy animals.

On the other hand, the livestock sector in the Central Rift Valley (CRV) around Ziway has been previously dominated by agro-pastoralists, which have been permanently settled by the effort of Government and NGOs. Currently, many of the smallholders using irrigation for crop production in the CRV are mixed crop-livestock farmers. However, the contribution of such scheme for livestock production in terms of feed supply is not well known. Yet, such smallholders keep livestock to provide them with draught power, transport, savings, and milk (Alemayehu, 1985; Legesse *et al*., 1987). Besides, the number of animals determines the socio-cultural status of the owner (Amsalu, 2000). The large number of animals in the CRV has resulted in large-scale overgrazing and land degradation as evidenced through the increase of invasive weeds. However, current baseline information with regard to feed availability is also lacking in the Central Rift Valley. Recently, dairy development is promoted by the government and NGOs to increase national milk production and to improve incomes of crop-livestock mixed farming systems. This development will contribute to the need of the society and at the same time increase competition for sufficient and good quality animal feed, especially roughage. Feed availability and quality, especially during the dry season is an important constraint in livestock production endeavor and it determines to a large extent the physical performance of the livestock sector. In general, it can be stated that the development potential of livestock production is negatively influenced by the chronic shortage of fodder in most of the livestock (both dairy and meat) producing areas. This study was therefore designed with the following specific objectives:

- To gain insight in the temporal and spatial availability of feed and its quality to target interventions in feed production and management in relation to livestock development in two production systems of Ethiopia.
- To investigate major constraints of feed supply in the selected areas.
- To assess the performance of cattle in the selected areas
- To develop advising strategies for livestock improvement.

2. LITERATURE REVIEW

2.1. Livestock Production Systems in Ethiopia

The diversity of Ethiopia's topography, climate and cultural conditions make it difficult to generalize about livestock production systems in the country (Alemayehu, 1985).Numerous authors used different criteria to classify livestock production systems in Ethiopia. However, about five production systems have been identified based on integration of livestock with crop production, level of input and intensity of production, agro-ecology and market orientation. The following systems have been defined viz. pastoral, agro-pastoral, mixed crop-livestock farming, urban and peri-urban dairy farming and specialized intensive dairy farming systems (MoA, 1997; Yoseph, 1999; Mohammed *et al*., 2004; Yitay, 2007).

In the lowland agro-ecological setup with pastoral production system, livestock do not provide inputs for crop production but are the very backbone of life for their owners, providing all of the consumable saleable outputs and, in addition, representing a living bank account and form of insurance against adversity (Coppock, 1994). This system is characterized by sparsely populated pastoral rangelands, where subsistence of the pastoralists is mainly based on livestock and livestock products. The livestock husbandry in this system is dominated by goats, cattle, sheep and camels. Since the main source of food is milk, pastoralists tend to keep large herds to ensure sufficient milk supply and generate income (IBC, 2004).

Agro-pastoral form of livestock production system dominates in mid agro-ecological zones where a tendency for crop production has shown besides livestock production. Agro-pastoralists are sedentary farmers who grow crops and raise livestock. Livestock are used for draught, savings and milk production. The production system is subsistence type of milk and or meat production (Zinash *et al*., 2001; Alemayehu, 2004). Cattle and small stock play a critical role in the agro-pastoralist household economy. Agro-pastoralists tend to retain female stock to produce milk and to maintain the reproductive potential of the herd. Oxen are also important for draft so that stock sold tend to be oxen and cows, which have lost their productive capacity. However, because average herd size is generally low, many herders are increasingly forced to sell young males and even females of optimum reproductive age (ILRI, 1995).

In the highland livestock production system, animals are part of a mixed subsistence farming complex (Alemayehu, 1987). Livestock provide inputs (draught power, transport, manure) to other parts of the farm system and generate consumable or saleable outputs (milk, manure, meat, hides and skins, wool, hair and eggs). About 88% of the human population, 70% of cattle and sheep, 30% of goats and 80% of equines are found in this region (Alemayehu, 2004). The principal objective of farmers engaged in mixed farming is to gain complementary benefit from an optimum mixture of crop and livestock farming and spreading income and risks over both crop and livestock production (Lemma and Smit, 2004; Solomon, 2004).

Urban and peri-urban production systems are developed in areas where the population density is high and agricultural land is shrinking due to urbanization around big cities like Addis Ababa and other regional towns. In this system crossbred animals (ranging from F1 to a higher blood level of exotic breeds mainly Holstein Friesian) are kept in small to medium-sized farms. Urban and peri-urban production systems include commercial to smallholder dairy farms. Such farms are reported to be found in and around major cities (Addis Ababa) and other regional towns. This sector own most of the country's improved dairy stock (Tsehay, 2002; Mohamed *et al*., 2003; Sintayehu *et al*., 2008). The main source of feed is both home produced or purchased hay and the primary objective is to get additional cash income from milk sale (Yitay, 2008).

Intensive dairy farming predominated by the state sector and urban and peri-urban private milk production has developed in and around major cities and towns with high demand for milk (Felleke and Geda, 2001). The system comprised of small and medium sized dairy farms located in the highlands are based on the use of purebred exotic or high grade and crossbred dairy stock. Farmers use all or part of their land for fodder production and purchase of concentrate is also another source of feed (Yoseph, 1999).

2.2. Dairy Production Systems in Ethiopia

Based on location or scale of market orientation and production intensity as criterion, three major dairy production systems are reported in Ethiopia (Azage and Alemu, 1998; Hizkias, 2000; Tsehay, 2002; Yoseph *et al*., 2003b; Zegeye, 2003; Dereje *et al*., 2005, Sintayehu *et al*., 2008). These are traditional smallholders, peri-urban and urban dairy production systems.

2.2.1. Traditional smallholder dairy production systems

The traditional smallholder system is part of the subsistence farming system, which includes pastoraslists, agro-pastoralists and mixed crop-livestock producers (Tsehay, 2002). It is roughly corresponding to the rural milk production system and supply 97% of the total national milk production and 75% of the commercial milk production. This sector is largely dependent on low producing indigenous breeds of cattle, which produce about 400-680 kg of milk /cow per lactation period (Gebre-Wold *et al*., 2000). The milk produced is mainly consumed by the household in the traditional system.

2.2.2. Peri-urban dairy production systems

This system is found in the outskirts of the capital city and regional cities and mostly concentrated with in 100 km distance around Addis Ababa which includes dairy farms ranging from smallholder to commercial farmers (Felleke and Geda, 2001). The main feed resources in this system include agro-industrial by-products and purchased roughage. The system comprises small and medium sized dairy farms that own crossbreed dairy cows. Dairy farmers use all or part of their land for forage production. The primary objective of milk production in this system is generating additional income to the household (Hizkias and Tsehay, 1995; Azage *et al*., 2000).

2.2.3. Urban dairy production system

It consists of dairy farms ranging from smallholder to highly specialized, state or businessmen owned farms, which are mainly concentrated in major cities of the country. These dairy farms have no access to grazing lands (Yitay *et al*., 2007) and basically keep exotic dairy stocks (Azage *et al*., 2000). Currently, a number of smallholder and commercial dairy farms are emerging mainly in the urban of the capital Addis Ababa (Felleke and Geda, 2001; Azage, 2004) and most regional towns and districts (Ike, 2002; Nigussie, 2006).

2.3. Socioeconomic Role of Livestock in Ethiopia

Livestock are an important component of nearly all farming systems in Ethiopia and provide draught power, milk, meat, manure, hides, skins and other products. In addition, livestock are important source of cash income and play an important role in ensuring food security and alleviating poverty (Ehui *et al*., 2002). The livestock sub-sector in Ethiopia accounts for about 12 and 33% of the total and agricultural gross domestic product (GDP), respectively, and provides livelihood for 65% of the population (Ayele *et al*., 2003). In the mixed crop-livestock systems of the Ethiopian highlands, livestock are subordinate but economically complementary to crop production in providing draft power, which is a vital contribution to the overall farm labor requirement. Livestock also provide meat, milk, cash income and manure, and serve as a capital asset against risk. In the semi-arid low lands, cattle are the most important species because they supply milk for the subsistence pastoral families. In the more arid areas, however, goats and camels are the dominant species reared. The former provide milk, meat and cash income, while the latter population for milk, transport and, to a limited extent, meat (Asfaw, 1997). Cattle are kept for all purpose. However, the purposes of keeping cattle vary with production systems. Traction ranked highest, followed by milk and reproduction/breeding (males and females) in both crop-livestock and agro pastoral systems (Alemayehu, 2004). Manure production also considered important by most crop/livestock and agro-pastoralist farmers, but as secondary rather than a primary purpose. In contrast, reproduction/breeding requirements received higher ranks in pastoralist systems and, for female, requirements for breeding outranked the importance of milk production (Workneh and Rowlands, 2004).

In Ethiopia, 45% of livestock owners are women and 33% of livestock keepers households are headed by women in Addis Ababa city (Azage, 2004). Women are usually responsible for feeding large animals, cleaning the barns, milking dairy cattle, processing milk and marketing livestock products, but they receive assistance of men, female children and/or other relatives. Young children, especially girls between the ages of 7 and 15, are mostly responsible for managing calves, chicken and small ruminants and older boys are responsible for treating sick animals, constructing shelter, cutting grass and grazing of cattle and small ruminants. The role of women in managing animals that are confined during most of the year is substantial. They are critically involved in removing and managing manure, which is made in to cakes and used or sold as fuel (Azage, 2004).

2.4. Land Holding and Land Use System in Ethiopia

The land size allotted to individual farmers by a Peasant Association (PA) as per the land reform declaration of 1975, depended on family size, fertility of the land, the number of PA members and the total land area available within the PA (Getachew *et al*., 1993). Most farms in Ethiopia are fragmented and smallholder mixed crop–livestock systems are interdependent. Increasing human population and diminishing land resources etc. are creating a growing number of landless people who also have to produce their own subsistence (Kebreab *et al*., 2005*).*Yitaye *et al.* (2007) reported that in the highland areas of Amhara region, where integrated farming is found, farmers owning on average 3.3 ha of land. The same report described that in urban areas where 75% of the farms do not have access to land, livestock farming and especially dairying is the main agricultural activity. In Southern Ethiopia at Alaba district, Yeshitila (2008) has reported that the average land size owned by a farmer is about 2.5 ha. The same report indicated that land and livestock holdings showed a direct linear relationship, where farmers with large land holdings have higher livestock holdings and when land holdings became smaller there is a trend of keeping more numbers of small ruminants than cattle.

2.5. Livestock Holding and Herd Structure

Livestock ownership varies depending on the wealth status and the overall farm production objectives. In mixed farming system of the highlands and mid-altitudes of Ethiopia where crop production is important; cattle are the most important livestock species for cultivation, threshing and manure (Getachew *et al*., 1993). Gryseels and Goe (1984) also reported that most farmers in the central highlands of Ethiopia own two oxen, a cow, few sheep and a donkey. Households with larger landholdings keep more animals because they need more draught power to cultivate the land, and this also enables them to produce more straw that helps to support a greater number of animals (Bayush *et al*., 2008).

By the expression ' flock/herd structure' it means that the proportion (in terms of number of head) of the herd of a single species which is formed by different age and sex classes of animals, e.g., breeding females, calves, mature bulls, mature oxen etc (ILCA, 1990). In mixed production systems where animals are used for draught and transport, the proportion of mature oxen or donkeys in herds tends to be relatively high (ILCA, 1990). In arid areas where pastoral system of production is dominant, livestock population has increased over time following the demand for both water and feed availability (Belaynesh, 2006).

2.6. Factors Influencing Dairy Production in Ethiopia

2.6.1 Cattle genotypes

According to Tsehay (1997), about 99% of the cattle population in Ethiopia are indigenous that are adapted to feed and water shortages, disease challenges and harsh climates. The productivity of indigenous livestock is, however, believed to be poor even if no practical recording scheme has been used to judge their merit. Crossbreeding has been practiced with encouraging results, however, a strictly controlled breeding program has not been practiced (Tesfaye, 1990) and there has been no dairy herd recording scheme. Less than 1% of the 49.3 million cattle populations of Ethiopia are exotic or crossbred dairy cows (CSA, 2008).

2.6.2. Market

Markets involve sales, locations, sellers, buyers and transactions (Debrah and Berhanu, 1991). Challenges and problems for dairying vary from one production system to another and/or from one location to another. The structure and performance of livestock and its products marketing both for domestic consumption and for export is generally perceived poor in Ethiopia. Lack of market-oriented production, lack of adequate information on livestock resources, inadequate permanent trade routes and other facilities like feeds, water, holding grounds, lack or non-provision of transport, ineffectiveness and inadequate infrastructural and institutional set-ups, prevalence of diseases, illegal trade and inadequate market information (internal and external) are generally mentioned as some of the major reasons for the poor performance of this sector (Belachew, 1998; Belachew and Jemberu, 2003; Yacob as cited in Ayele *et al*., 2003).

The primary selling outlet of milk is direct sell to consumers and price of dairy commodities are determined by different factors such as season, access to market/distance from towns, fasting and non-fasting days, festivals and holidays, level of supply vs. purchasing ability of the urban dwellers, and quality and sources of dairy products (Sintayehu *et al*., 2008). The same authors also reported that the major constraints for dairy development in the southern Ethiopia included availability and costs of feeds, shortage of farm land, discouraging marketing systems, waste disposal problems, lack of improved dairy animals, poor extension and animal health services, and knowledge gap on improved dairy production, processing and marketing.

2.6.3. Feed resources

Inadequate supply of quality feed and the low productivity of the indigenous cattle breeds are the major factors limiting dairy productivity in Ethiopia. Feed, usually based on fodder and grass, are either not available in sufficient quantities due to fluctuating weather conditions or when available are of poor nutritional quality. These constraints result in low milk and meat yields, high mortality of young stock, longer parturition intervals, and low animal weights (McIntire *et al*., 1992). Improved nutrition through adoption of sown forage and better crop residue management can substantially raise livestock productivity. National and international research agencies, including the International Livestock Research Institute (ILRI), have developed several feed production and utilization technologies and strategies to address the problems of inadequate and poor quality of feeds.

The major feed resources in the highland are natural pasture, crop residues and stubble grazing (Alemayehu, 2004). The availability of feed resources in the highlands depends on the intensity of crop production, population pressure, the amount of rainfall, and distribution pattern of rainfall and seasons of the year (Mohammed and Abate, 1995). Pasture growth is a reflection of the annual rainfall distribution pattern (Seyoum *et al*., 2001). However, with the decline in the size of the grazing land and degradation through overgrazing and the expansion of arable cropping, agricultural by-products have become increasingly important (Alemu *et al*., 1989; Abate and Abiye, 1993; Getnet, 1999; Alemayehu, 2004).

Native pasture is the major source of feed for ruminants both in the area of mixed farming system and pastoralism, although it is neither quantitatively nor qualitatively adequate to support profitable animal production (Seyoum *et al*., 1997). In addition, *tef* and wheat straws are also important sources of livestock feed in the highland vertisol areas. Barley and oat straws are also important in areas where they are produced. Straw supplementation is commonly restricted to work-oxen and lactating cows.

At present, the production of improved pasture and forages is insignificant and the contribution of agro-industrial by-products is also minimal and restricted to some urban and peri-urban farms (Alemayeu, 2005). The same author also indicated that in the past two decades, considerable efforts have been made to test the adaptability of pasture and forage crops to different agro ecological zones and several useful forages have been selected for different zones.

Seasonality of plant growth, which is a reflection of annual rainfall distribution pattern, restricts the availability of herbage for grazing animals to 4 or 5 months of the wet season for most of the natural grasslands (Iowga and Urid, 1987). Moreover, Tothil (1987) reported that feed for livestock arising from natural pasture fluctuates considerably in such quality components as protein and fiber which are generally inversely proportional to each other. On the other hand, many surveys and studies conducted in Ethiopia and elsewhere in the world indicate that cereal straw, dry by-products of crops and aftermath are available after the crop harvest i.e. in the dry season (Taylor, 1984; Preston and Leng, 1984; Verjux, 1988; Seyoum and Zinash, 1988).

In Ginchi watershed area, Getachew (2002) has reported that the quantity of feed was inadequate in the dry season for the existing livestock while there is surplus in the wet season.

Quantitatively, stubble grazing and crop residues also serve as important sources of feed. Cereal crop residues (straws and stovers) are mostly stacked and fed to livestock during the dry season when the quantity and quality of available fodder from natural pasture declines drastically (Adugna and Said, 1994).

Hay is commonly used way of feed preservation technique in Ethiopia which is expected to mitigate problems of livestock feeding during the dry period and therefore such experience is a good indicator that feeds are being efficiently utilized. High quality hay can be defined as forage that is dried without deterioration and retaining most of its nutrients. Moreover being freedom from mould development, retention on natural color and palatability and capability for storage over a long period of time are other important desirable qualities considered in hay. Many farms in urban and peri-urban areas livestock farm owners rely on bought fodder which is irregularly available and often of dubious quality (Vernooij, 2007).

2.7. Nutrient Requirement of Cattle

Generally, cattle require nutrients for maintenance, growth, production and reproduction. Nutrients required for these functions are expressed in terms of energy, protein, minerals (particularly calcium and phosphorous) and vitamins. Energy, protein, and digestibility of feeds are central in determining nutritional adequacy and feeding levels for different classes of stock (Streeter, 2006). Energy is usually the most important feed component needed to produce milk. The energy needed depends on the composition of the milk (i.e., fat and protein content). The value of feed is clearly related to the amount of energy it can supply, since energy is usually the chief limiting nutrient (Wilson and Brigstocke, 1983). According to McDonald and Greenhalgh (1988), energy requirement of animals is most commonly expressed in the simplest way possible as the absolute quantities of energy gained or lost by animals. Energy for maintenance can be defined as the amount of feed energy required for essential metabolic processes and physical activity, which results in no net loss or gain from, or to the tissues of the animal (NRC, 1996). Demand for energy depends on breed, live-weight, sex and physiological state (pregnancy, lactation) of the animal. The amount of feed needed to meet maintenance requirements will vary with the type and quality of feed available.

Proteins are the main constituents of an animal body and are continuously needed in the feedstuff. The protein content of herbage falls with the phosphorous so that protein deficiency, and frequently also a deficiency of available energy, are exacerbating factors in the malnutrition of livestock in phosphorous deficient areas (Eric, 1981). With increasing crude protein concentrations, milk yield increased by 4.0 kg/day at the same concentrate intake but tended to fall at reduced concentrate intake (Sutton *et al*., 1996).

Calcium (Ca) and phosphorus (P) are closely correlated for building the skeletal structure. Approximately 90% of the calcium and 70% of the phosphorus can be found in skeleton and teeth. Phosphorus in addition to its function in bone building is also required in the utilization of energy and in the cell structure. They are also the ones most often added to ruminant diets. Animals usually require 1.5 parts of Ca for every part of P. Phosphorous deficiency can be regarded as the most prevalent and serious mineral limitation to livestock production (McDowell, 1985). However, to meet the dietary requirements of cattle, P supplementation should be seriously considered. The dietary P concentration needed to meet dietary requirements varies widely with feed intake, breed, body weight, growth rate and physiological state (Chantiratikul *et al*., 2009). Kearl (1982) recommended P requirements for tropical beef cattle ranging from 1.7-3.5 g kg^{-1} feed.

2.8. Reproductive and Productive Performance of Cows

Reproductive performance of a cow is measured by several factors such as age at first calving, calving interval, days open and number of services per consumption (Dematawewa and Berger, 1998). On the other hand, productive performance of cows is measured by daily and lactation milk yield. However, both productive and reproductive performance are influenced more by genotype and environmental factors such as nutrition, management and climate.

2.8.1 Age at first calving

Age at first calving determines the beginning of the cow's productive life and influences her lifetime productivity (Ojango and Pollott, 2001). Age at first calving has a significant influence on the total cost of raising dairy replacements with older calving heifers being more expensive to raise than younger (Tozer and Heinrichs, 2001). Estimated age at first calving for Ethiopian cattle ranges from 35-62 months (McDowell, 1972; Kiwuwa *et al*., 1983; Alberro, 1983; Mekonnen and Goshu, 1987; Mukasa-Mugerwa, 1989; Mulugeta *et al*., 1991; Hailemariam and Kassamersha, 1994; Ababu, 2002). There are different factors that advance or delay age at first calving. The time taken by an animal to attain puberty and sexual maturity depends among others on the quality and quantity of feed available, which affects growth rate. There has been substantial evidence that dietary supplementation of heifers during their growth will reduce the interval from birth to first calving (Kayongo-Male *et al*., 1982), probably because heifers that grow faster will cycle earlier and exhibit behavioral estrus. Breed difference among cattle had also significant effect on age at first calving (Mukasa-Mugerwa, 1989).

2.8.2. Age at first service

It is the age at which heifers attain body condition and sexual maturity for accepting service for the first time. It influences both the productive and reproductive life of the female through its effect on her lifetime calf crop. Age at first service is influenced by genotype, nutrition and other environmental factors. Alberro (1983) reported an earlier age at puberty for zebu crosses than for the local zebu animals. Besides, the age at first service was reported to be 44.8 months for Fogera breeds (Giday, 2001), 40.2 months for white Fulani and 21.7 months for crossbreds (Fulani X Friesian) in Nigeria (Knudeson and Sohael, 1970). Nutritional status is one of the variables influencing the onset of puberty, which has been relatively well-defined (Schillo *et al*., 1992). Moreover, irregularities in feed supply and differences in management systems may bring about variations in age at first service in different areas (Gebeyehu *et al*., 2005).

2.8.3. Days open

An increase in the number of days between calving and conception, also known as days open, influences profitability of the dairy industry. This influence is partly attributed to factors such as increased breeding cost, increased risk of culling and replacement costs, and reduced milk production (de Vries and Risco, 2005). Days open is influenced by breeds of cattle. Mekonen (1987) reported that mean days open periods for pure Fogera and F1 Friesian X Fogera were

151±1 and 151±4 days, respectively, whereas, ¾ Friesian XFogera crosses had 361±4 days. Days open affect lifetime production and generation interval (Ababu, 2002). The days open period should not exceed 80 to 85 days, if a calving interval of 12 months is to be achieved (Peters, 1984; Enyew, 1992). This requires re-establishment of ovarian activity soon after calving and high conception rates. Kefena (2004) also reported the mean length of days open to be 200.1±25.6 days for Boran crossbred. Nutritional deficiencies coupled with heavy internal and external parasite load under extensive management systems, and allowing calves to suckle their dams may all interfere with ovarian function, thereby prolonging the days open (Short *et al*., 1990; Hafez, 1993). The effect of low level of nutrition on extended postpartum period due to weight loss was noted by Gebreegziabher *et al.* (2005). Moreover, Tadesse and Zelalem (2004) reported that increasing the level of protein supplementation from low (2kg/day) to high (4 kg /day) reduced the post partum interval from 159 to 100 days. Cows that are over conditioned at calving or those that lose excess body weight are more likely to have a prolonged interval to first oestrus, which could result in longer days open (James, 2006).

2.8.4. Calving interval

Calving interval is a function of calving-to-conception interval or days open, which is considered to be the most important component determining the length of calving interval, and gestation length, which is more or less constant. Calving interval varies slightly due to breed, calf sex, calf size, dam age, year, and month of calving. Mukasa-Mugerwa *et al*. (1991) and Kiwuwa *et al*. (1983) reported the mean calving interval of 459 ± 4 days for crossbred cattle in Arsi region Ethiopia. Estimates of calving interval in zebu cattle range from 12.2 to 26.6 months (Mukassa- Mugrewa, 1989). Age at first calving can be reduced with reasonably good management (Kiwuwa *et al*., 1983). Nutritional conditions that vary seasonally and yearly have major effects on calving interval (Oyedipe, 1982; Hailemariam and Kassamersha, 1994). Lower conception rates, longer calving intervals and an increased incidence of silent heat have been considered to be the results of energy deficiency (Otterby and Linn, 1981). Increased calving interval is undesirable, particularly in a production system in which there is a high demand for pregnant or lactating heifer. This can occur if a higher yielding animal produces fewer replacements, due to negative phenotypic correlation between calving interval and milk production. However, Österman and Bertilsson (2003) suggested that by combining a longer calving interval with increased milking frequency, daily milk production from one calving to another could be increased, making an increased calving interval an interesting option for dairy farmers.

2.8.5. Milk yield and lactation length

Milk production is affected by genetic and environmental factors. Among the environmental factors, the quantity and quality of available feed resources are the major ones. Inadequate level of nutrition has been found to be the most important factor influencing length of post partum anoestrus in cows grazing tropical pasturelands (Topps and Oliver, 1993). The milk production potential of indigenous cattle breeds is very low. However, milk production potential of temperate breeds under improved management in the tropical environments is higher than the indigenous breeds (Syrstad and Ruane, 1998). Body condition and body weight are important variables indicating the nutritional status and expected performance of dairy cows. The plane of nutrition to which an animal has been exposed over a reasonable length of time is reflected by the extent to which fat is stored or muscle has diminished and these are assessed by condition score and live weight change (Mukasa-Mugerewa, 1989). Cows having optimum body condition and weight imply that they have been maintained under good feeding and are expected to produce and reproduce efficiently. In general, the quality and quantity of feed resources available to dairy cows determine the corresponding body condition and body weight.

In most dairy farms a lactation length of 305 days is commonly accepted as a standard. However, such a standard lactation length might not work for smallholder dairy cows where the lactation length is extended considerably in most cases (Msangi *et al*., 2005). The profitability of short or extended lactation length depends on various factors, including the lactation length persistency. Numerous studies have documented that additional days in which cows are not pregnant beyond the optimal time post calving are costly (Groenendaal *et al*., 2004; Meadows *et al*., 2005). According to a report by Tawah *et al*. (1999) lactation performance of pure breed Arsi and crosses with Friesian kept at Assela station in the Arsi region of Ethiopia, was not affected by pre-partum supplementation with concentrate mixes, however, it was significantly and positively affected by postpartum concentrate supplementation. However, Borman *et al*. (2004) demonstrated that extended lactations are suitable for some dairy enterprises and that the suitability depends particularly on cow milk potential, the ability to grow pasture or feed supplements economically, management expertise, environmental constraints, herd size and labor availability.

3. MATERIALS AND METHODS

3.1 Overview of the Study

This study was conducted in two livestock production systems viz. peri-urban dairy system of the highlands and mixed-crop livestock system of the Central Rift Valley (CRV). Debre Birhan, Sebeta and Jimma were considered to represent the highland peri-urban dairy system while Ziway was a representation of CRV livestock production system. In this study, peri-urban system constitutes those dairy farms which are located outside of the city/town's boundary (a distance of 5 to 10 kilometers), produce milk and deliver the same to city/towns. Crossbred cows with any exotic blood level inheritance were used for the peri-urban dairy system of the highland. Variables under productive and reproductive performance of cattle were estimated based on the farmer's estimation.

3.2. Description of the Study Areas

Debre Birhan is found in North Shoa administrative zone of the Amhara National Regional State and is located 130 km north of the capital Addis Ababa, at 39°30' East longitude and 09°36' North latitude. It is a typical highland area with an elevation of 3360 masl. It has a bimodal rainfall distribution with short and long rainy seasons covering from March to April and June to September, respectively. It receives an annual average rainfall of 731-1068mm, and has an annual temperature range of 6-20 ^{O}C (Ahmed, 2006). About 52% of this *Woreda* falls under the highland (*Dega*) agro-ecological zone, which is characterized by severe frost attack every year from October to December. Major crops grown around this area are cereals such as barley, wheat, field pea, faba bean and chickpea. Barley straw constituted the largest share of crop residue fed to livestock.

Sebeta is located 25 km Southwest of Addis Ababa and situated at a latitude and longitude of 8°55′N, and 38°37′E, respectively. It has an elevation of 2356 meters above sea level. The area is classified as temperate highland or «*Dega*», with an annual rainfall of about 1650 mm. The mean annual minimum and maximum temperature is 8 ^{O}C and 19 ^{O}C, respectively. Sebeta is the administrative center of Alem Gena *Woreda.* Based on the report of Central Statistical

Agency (CSA, 2008) Sebeta town has an estimated total human population of 56,131 of whom 27,862 were males and 28,269 were females.

Jimma is located at 350 km away from the capital Addis Ababa. It is the largest city in the South Western Ethiopia. It lies between 36^0 10´ E longitude and 7^0 40´ N latitude (Dechassa, 2000). Its altitude is 2060 masl. Farmers in the area practice mixed crop-livestock farming. The zone is one of the major coffee growing areas of southwest Ethiopia; cultivated and wild coffee is a main cash crop of the area. Jimma zone is well endowed with natural resources contributing significantly to the national economy of the country. Major crops grown, other than coffee, are maize, tef (*Eragrostis tef*), sorghum, barley, pulses (beans and peas), root crops (E*nset*-false banana and potato) and fruits. *Tef* and honey production are another sources of cash after coffee. *Enset* (*Ensete ventricosum*) is a strategic crop substantially contributing to the food security of the zone (CSA, 2004). According to Jimma Zone Meteorology Station Report (JZMSR) (2004), the climate is humid tropical with bimodal heavy annual rainfall, ranging from 1200 to 2800 mm. In normal years, the rainy season extends from February to early October. The thirteen years mean annual minimum and maximum temperature of the area was 11.3 ^{O}C and 26.2 ^{O}C, respectively. Based on the report of Central Statistical Agency (CSA, 2008) Jimma has an estimated total human population of 810598 of whom 407813 were males and 402785 were females.

Ziway area representing Central Rift Valley is situated at a distance ranging from 130 to 160 km south of the capital, Addis Ababa. The altitude of this area lies from 1500-1700 masl. The average annual rainfall of the area is about 688 mm and its mean maximum and minimum temperatures are 27.2^0C and 14.4^oC, respectively. Based on figures from the Central Statistical Agency (CSA, 2008) an estimated total human population at Ziway and its surrounding were 287710 of whom 146398 were males and 141312 were females.

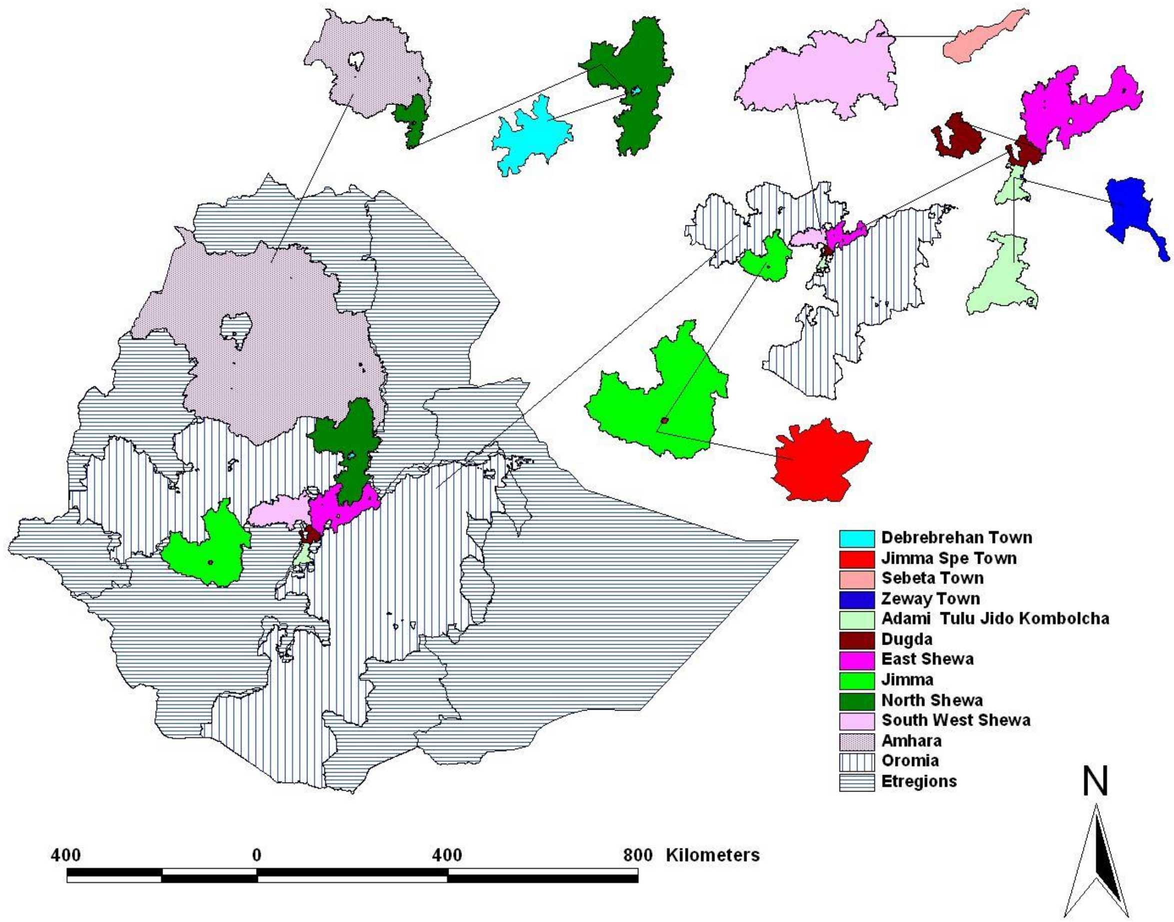


Figure 1 Map of the study sites

3.3. Sampling Procedures

A reconnaissance survey was conducted in order to select specific peasant associations (PA), livestock farmers and to get general picture of the study sites. Secondary information from *Woreda* and Zonal Agricultural and Rural Development offices was also utilized to assist in the selection of PAs. The highland peri-urban dairy system was represented by Debre Birhan, Jimma and Sebeta, which were later stratified into small and medium herd size dairy farms based on the number of crossbred cows they possess. Large scale commercial dairy farms (own more than 10 crossbred dairy cows) were not considered in this study since they are already part of the commercial system and relatively better access to feed and other resources. Accordingly, dairy farms with less than three crossbred dairy cows were categorized as small herd size, while those who had above 3 and less than 10 were considered as medium herd size (ILRI, 1996). Twenty dairy farms (10 from each small and medium herd size) were purposively selected from the peri-urban system of each town in the highland production system. Thus, a total of 60 dairy farms (20 from each site) were selected from the highland peri-urban areas.

The mixed crop-livestock production system of the Central Rift Valley was represented by Ziway area. A total of 9 PAs were identified from Ziway and the surrounding areas based on accessibility and availability of livestock. A total of 60 farmers from 9 PAs were selected purposively from the list of farmers who had livestock based on the same criteria.

In both production systems, a total of 120 respondents were selected for the study. For both production systems a structured questionnaire was prepared and pre-tested for its applicability before its administration. Interview was done by the researcher together with the livestock experts and development agents from the respective agricultural offices. These experts were used as translators for the local language '*Oromifa'* and as a local guide to lead to the selected farmers. The interviews were carried out at the farmer's home to enable counterchecking of the farmer's response with respect to the availability of feed resources, livestock population and species and the overall management system of the farm. A group discussion was also organized around Ziway with purposively selected elder farmers, who had long experience and knowledge of livestock raising so as to collect qualitative data and prioritize livestock production problems.

The following data were collected using questionnaire: household structure, farm size, land use pattern, herd size, herd composition, purpose of livestock raising, daily milk yield, major crops grown, crop grain yield, livestock feed types, feed markets, milk price, milk market places, age at first parturition, calving interval, lactation length, days open, mating systems, dry matter (DM) production, quantity of total feed and types of housing for livestock.

3.4. Feed Quantity Assessment

The quantity of feed dry matter obtainable from natural pastures were determined by multiplying the hectare under each land use category by their respective estimated annual DM yield per hectare i.e. 2.0 t/ha (FAO, 1984, 1987). The amount of purchased dry forages such as hay and straw was determined by estimating a single donkey load or lorry load and for baled hay by asking how many bales of hay would be purchased for a year. Whenever record was available, the quantity of purchased feeds was considered from the record. The quantity of available crop residues produced by farmers was estimated by applying grain to straw ratio as suggested by FAO (1987). Accordingly, for a ton of wheat, barley, oat and *tef* straw, a multiplier of 1.5 was used for faba bean, field pea, chick pea and haricot bean straw a multiplier of 1.2 used for maize a multiplier of 2.0 was used and for sorghum a multiplier of 2.5 was used. The quantity of potentially available crop residue for animal consumption was estimated by assuming 10% wastage (Adugna and Said, 1994). The amount of grain yield obtained from the respective crops was quantified by interviewing the farmers and cross checking it with the data recorded by development workers for any deviation. The quantity of concentrates and non-conventional feed resources were estimated by interviewing the farm owners with regard to the frequency and quantity purchased per month. The grazing potential of crop stubbles was estimated using a mean of 0.5 ton per ha as reported by FAO (1987). The potential fodder yield of shrubs and trees were estimated by measuring stem diameter using measuring tape and using the equation of Petmak (1983). Accordingly leaf yield of 144 fodder trees was predicted by using the allometric equation of $\log W = 2.24 \log DT - 1.50$, where W = leaf yield in kilograms of dry weight and DT is trunk diameter (cm) at 130 cm height. Similarly, trunk diameter (DT) can be obtained by: $DT = 0.636C$; where C=circumference in centimeter (cm). For the leaf yield of a shrub the allometric equation used was $\log W = 2.62 \log DS - 2.46$, where DS is the stem diameter in cm at 30 cm height.

3.5. Estimation of Forage Biomass Yield

To determine the potential forage biomass yield and dry matter production in the Central Rift Valley, representative samples of grass and herbaceous vegetation were taken from an enclosure. The site used for enclosure was made by the local NGO named as Selam

Environmental Development Association (SEDA) 15 years ago. The enclosure was kept by guards with the help of local bylaw, which was set together with the surrounding community. In the wet season, it was totally protected from livestock entrance and in the dry season only few numbers of oxen are allowed to graze. Representative samples of grass, legumes and other forbs were taken by making transect lines. Palatable grasses species in natural vegetation were identified together with herders and range expert and further classification was made as decreasers, increasers and invaders (Baars *et al*., 1997; Ahmed, 2006). Sampling was done from the 15th August to 15th September 2008 when almost all the pasture plants were fully grown to their 50% flowering stage.

In each quadrat (1m x 1m), harvesting was done at the ground level. From each quadrat fresh weight of harvested samples was taken immediately by using a spring balance of 20 g precision. For further chemical analysis, a composite sample was taken from the bulk samples. A composite sample was transported to Adami Tullu Agricultural Research Center nutrition laboratory and dried in an oven at 105 ^{O}C overnight for dry matter determination. For chemical analysis, the same feed samples were dried in an oven at 60 ^{O}C to a constant weight. Oven dried feed samples were thoroughly mixed by feed type and ground to pass through 1 mm sieve. Then the ground sample was transported to Holetta Agricultural Research Center for chemical analysis.

3.6. Assessment of Livestock Feed Requirement

The annual availability of feed was compared with the annual requirements of the livestock population. Livestock populations were converted in to Tropical Livestock Unit (TLU) as suggested by Gryseels (1988) for indigenous zebu cattle and Bekele (1991) for crossbreds. The dry matter (DM) requirements for maintenance were calculated based on daily DM requirements of a 250 kg dual-purpose tropical cattle (an equivalent of one TLU). Nutrients supplied by each feed types were estimated from the total DM output and nutrients content of that feed on DM basis (Abdinasir, 2000; Tsigeyohannes, 2000). The total nutrient requirements (DM, crud protein (CP) and metabolizable energy (ME)) per day per livestock species were estimated based on the recommendations of Kearl (1982) and McCarthy (1986) for tropical livestock (Appendix Table 2).

3.7. Chemical Analysis of Feed Samples

Chemical analysis of feedstuffs was performed at Holetta Agricultural Research Center nutrition laboratory. DM and ash contents of feed samples were determined by oven drying at 105 ^{O}C overnight and by igniting in a muffle furnace at 600 ^{O}C for 6 hour, respectively (AOAC, 1990). Nitrogen (N) content was determined by Kjeldahl method and Crude Protein (CP) was calculated as N*6.25 (AOAC, 1995). Calcium (Ca) and phosphorous (P) content were determined by atomic absorption spectrophotometry (Perkin, 1982). Acid Detergent Fiber (ADF), Acid Detergent Lignin (ADL), Neutral Detergent Fiber (NDF), and *In vitro* Digestible Organic Matter in the Dry Matter (IVDOMD) were determined by the modified Tilley and Terry method (Van Soest and Robertson, 1985). Metabolisable Energy (ME) and Digestible Crude Protein (DCP) content of a particular feed were estimated from IVDOMD and CP contents, respectively, as per the following equations.

ME (MJ/kg DM) =0.015*IVDOMD (g/kg). (MAFF, 1984).

DCP (g) = 0.929*CP (g) -3.48. (Church and Pond, 1982).

3.8. Milk and Feed Price Assessment

Data on price of milk and feed was collected from each site at the time of the survey period (for a maximum of two months) from market as well as through interviewing the farmer/producer, retailers and using some records from dairy cooperatives.

3.9. Statistical Analysis

Data collected were stratified into production systems and analysed using Statistical Analysis System software (SAS, 2002). Descriptive statistics were employed to describe qualitative variables. General Liner Model (GLM) procedure of SAS was employed to analyse the effect of classification variables. Means separation was done using Tukey adjustment.

Statistical Models

Model I. General Model: Peri-urban dairy in the Highland and CRV mixed crop-livestock production system.

$y_{ijk}= \mu+P_i+S_j+e_{ijk}$

Where,

y_{ijk}= Household variables

μ=overall mean

P_i= the effect of i[th] production system

S_j= the effect of j[th] study sites

e_{ijk}= random error

Model II. Specific to Peri-urban dairy production system of the Highland

$y_{ijk}=\mu+ S_j+ H_i +(SH)_{ij} +e_{ijk}$

Where,

y_{ijk}= Productive and reproductive performance of dairy cows

μ=overall mean

S_j= the effect of j[th] study sites

H_i= the effect of i[th] herd size

$(SH)_{ij}$= the interaction effect of study sites and herd size

e_{ijk}= random error

Model III. Specific to Central Rift Valley mixed crop-livestock production system.

$y_{ij}= \mu+PA_i+e_{ij}$

Where,

y_{ij}= Productive and reproductive performance of cows

μ=overall mean

PA_i= the effect of i[th] Peasant Associations (PA)

e_{ij}= random error.

4. RESULTS AND DISCUSSION

4.1. Farming Systems Characteristics

4.1.1. Household characteristics

In the Highland (Debre Birhan, Sebta and Jimma) system, about 86.7% of the respondents were male dairy farmers while 13.3% were females (Table 1). In the Central Rift Valley (around Ziway) out of 60 livestock farmers considered, 93% and 7% were male and female headed households, respectively. The results of the current work differ from the report of Azage (2004) who reported 33% female headed households and 67% male headed household livestock keepers in Addis Ababa. Less number of female headed households involved in livestock keeping in the current study could probably be due to cultural issues that force females to get married and/or for economic reason. Of the interviewed households in the Central Rift Valley (CRV), 68% of the household heads had one wife while the rest 30% had two or more wives and the remaining 2% did not marry yet. Polygamy type of marriage is fairly uncommon in the highland study areas as compared to the Central Rift Valley. The average number of children per household in the highlands was 1.6 while for CRV the average was 5.2. It could presumably be associated with the wealth status and a number of children are required so as to meet the labor force for different farm operations and also considered as a means of security in CRV. Similarly, study by Agajie *et al*. (2005) indicated that having many wives is one of wealth indicators and commonly practiced type of marriage in the Central Rift Valley.

Table 1 Demographic characteristic of the respondents in the highlands and Central Rift Valley production systems

Household variables	Highland				Central Rift Valley
	DB	Jimma	Sebeta	Total	Ziway
Sex of household head	n=20	n=20	n=20	n=60	n=60
Male (%)	100.0	80.0	80.0	86.7	93.3
Female (%)	0.0	20.0	20.0	13.3	6.7
Over all (%)	100	100	100	100	100
Children	n=48	n=30	n=23	n=101	n=314
Mean	2.4	1.5	1.2	1.6	5.2
Wives					
	n=20	n=20	n=20	n=60	n=60
One (%)	100.0	80.0	80.0	86.7	68.3
Two (%)	0.0	0.0	0.0	0.0	23.3
Three (%)	0.0	0.0	0.0	0.0	6.7

DB= Debre Birhan, n=number of respondents

The educational level of the households was better in Highland production systems (Debre Birhan, Jimma and Sebeta) than Central Rift Valley. Thus, about 45% of the farmers in Highland production system have attended either high school or college education compared to 10% in CRV (Table 2). On the other hand, about 3.3% farmers in the Highland production system were illiterate while the figure for CRV was 18.3%. The difference could be attributed to better access of schools in the Highland system compared to the CRV. About 40% of the dairy farmers in Sebeta and 55% of the dairy farmers in Jimma had attended secondary school or college. Within the Highland system, about 10% of the respondents in Debre Birhan were illiterate. Farmers with high education levels adopt usually new technologies more rapidly than lower educated farmers (Ekwe and Nwachukwu, 2006; Ngongoni *et al*., 2006; Ofukou *et al*., 2009).

Table 2 Educational level of respondents (household heads) across the study sites

Production system	Study sites	Illiterate (%)	Read and write only (%)	Primary school (%)	Junior secondary school (%)	High school (%)	Above high school (%)	Total (%)
Highland								
	DB (n=20)	10.0	35.0	30.0	10.0	15.0	0.0	100.0
	Jimma (n=20)	0.0	5.0	20.0	0.0	20.0	55.0	100.0
	Sebeta (n=20)	0.0	10.0	30.0	15.0	40.0	5.0	100.0
Subtotal (n=60)		**3.3**	**16.7**	**26.7**	**8.3**	**25.0**	**20.0**	100.0
CRV								
	Ziway (n=60)	18.3	13.3	45.0	13.3	8.3	1.7	100.0
Overall (n=120)		**10.8**	**15.0**	**35.8**	**10.8**	**16.7**	**10.8**	**100.0**

Note: "Educational status of household heads" spans the columns from Study sites to Total (%).

DB= Debre Birhan, n= number of respondents.

The average family size per household across the surveyed areas was 8.9±0.5 (Table 3). The family size in the CRV (around Ziway) was significantly ($P<0.05$) higher than the Highland production system (Debre Birhan, Jimma and Sebeta). However average family size did not differ ($P>0.05$) among Debre Birhan, Jimma and Sebeta study sites. The large family size around Ziway area could be related to the relatively labour intensive diversified farming activities and the weak family planning services. The average number of both males and females with in the household was higher ($P<0.05$) for CRV as compared with the Highland study sites.

The age of respondents interviewed ranged from 23 to 78 years old with a mean age of 47±1.7 years old. The mean number of family members in a non-productive age category per household was higher ($P<0.05$) in the Central Rift Valley than in the Highland production system. The difference might be associated with number of children. In Jimma and Sebeta areas hired labor was living together with the household and considered as a member of the family. On the other hand in Debre Birhan and around Ziway areas livestock related activities were exclusively undertaken by the family members.

Table 3 Mean (±SE) of household family sizes, active and non-active labor group and gender distribution in the Highlands and Central Rift Valley systems

Production system	Age of respondents	Family size/household			Non-productive age*	Productive age**
		Male	Female	Total		
Highland						
DB (n=20)	48.6±2.2	3.7±0.2[b]	3.7±0.3	7.4±0.2	2.5±0.3	4.9±0.4
Jimma (n=20)	48.4±2.7	4.2±0.4[ab]	3.3±0.3	7.5±0.5	1.6±0.4	6.0±0.5
Sebeta (n=20)	45.8±3.8	3.4±0.3[b]	3.7±0.4	7.1±0.6	1.3±0.2	5.8±0.6
Mean (n=60)	**47.6±1.7**	**3.8±0.3[b]**	**3.6**±0.2[b]	**7.3**±0.5	**1.8 ±0.3[b]**	**5.6±0.3**
CRV						
Ziway (n=60)	46.3±1.8	5.3±0.4[a]	5.2±0.3[a]	10.5±0.6	5.6±0.4[a]	4.9±0.3
Overall mean (n=120)	**46.9±2.6**	**4.5±0.3**	**4.4±0.3**	**8.9±0.5**	**3.7±0.3**	**5.2±0.5**

[a-b] means in the same column sharing different letters of superscripts are significantly different ($P<0.05$), HH=Household, DB=Debre Birhan, * Family members less than 15 and above 65 years old as 'non-productive age' (CSA, 1999), ** Family members of 15 to 65 years old as 'productive age' (CSA, 1999).

4.1.2. Landholding and land use pattern

In this study, it has been observed that farmers own land only in Debre Birhan from Highland production system and in Ziway from Central Rift Valley mixed crop-livestock production system; whereas in Jimma and Sebeta the interviewed farmers did not have any farmland. Thus, the overall average private land holding per household in Debre Birhan was 1.8 ha, out of which 1.1 and 0.7 ha of land were allocated for crop production and grazing, respectively (Table 4). Surprisingly, in this area, the largest share of land used for crop production, grazing and or grass hay making was obtained every year through contractual/rent basis. The relatively small size of the landholdings in Debre Birhan compared to CRV is related to the high population density in the Highlands.

In the Central Rift Valley (CRV), the average landholding (4.2±0.4 ha) was substantially larger than Debre Birhan. About 3.2 ha of land was used for crop production and 1.3 ha for grazing pastureland. The amount of land contracted/rented in for crop farming and livestock grazing was smaller than the area owned by each household. Hay making from grass for animal feed is rare in this area and own grazing land plus contract/rent lands used as grazing resources during the heavy rainy seasons.

Major crops grown and their area coverage in Debre Birhan include barley (1.6 ha), wheat (0.5 ha) field pea (0.7 ha), faba bean (0.5 ha). Common crops grown and their coverage in Ziway includes maize (1.4 ha), wheat (0.9 ha), haricot bean (0.7 ha), *tef* (0.6 ha) and barley (0.4 ha). Maize and haricot bean are well adapted to the Ziway area (lowland). The largest land per household was allotted for barley crop in Debre Birhan but for maize crop in the Central Rift Valley (Ziway).

Table 4 Average landholdings per household and land use pattern in Debre Birhan and Ziway

	Debre Birhan		Overall DB	Ziway
	Small herd size n= 10	Medium herd size n=10	n=20	n=60
Landholding (ha)				
Total own land*	1.5±0.1	2.2±0.3	1.8±0.2^{b}	4.2±0.4^{a}
Own cropland	1.0±0.1	1.2±0.2	1.1±0.1^{b}	3.2±0.3^{a}
Own grazing land	0.5±0.1	1.0±0.1	0.7±0.1	1.0±0.2
Contracted/rented				
Cropland	2.1±0.5	2.2±0.4	2.1±0.3^{a}	0.7±0.2^{b}
Grazing land	0.6±0.2	0.6±0.1	0.8±0.1	0.4±0.1
Land allocated for crops (ha)				
Wheat	0.5±0.1	0.5±0.1	0.5±0.1^{b}	0.9±0.1^{a}
Barley	1.5±0.3	1.8±0.2	1.6±0.2^{a}	0.4±0.1^{b}
Tef	0.1±0.0	-	0.1±0.1^{b}	0.6±0.1^{a}
Field pea	0.2±0.1	0.1±0.0	0.7±0.2	-
Faba bean	0.5±0.2	0.3±0.1	0.5±0.1	-
Oats	0.4±0.1	0.6±0.2	0.5±0.1	-
Maize	-	-	-	1.4±0.2
Haricot bean	-	-	-	0.7±0.1

$^{a-b}$ means in the same row with different letter of superscripts are significantly different from each other (P<0.05), * own land excluding contracted/rented land, n =number of respondents, DB= Debre Birhan.

4.1.3. Crop yields

The average grain yield of field crops and their residue yield in Debre Birhan and Ziway study sites is shown in Table 5. During the study period, some of the crops failed to produce grain seed because of late and untimely rainfall around Ziway and because of ice, pulse crops in Debre Birhan. Partly these circumstances might underestimate the dry matter yield obtained from some crop residues. The grain yield was relatively high for barley in Debre Birhan and for maize in Ziway area. The major crop residue yield in Debre Birhan was contributed by barley, oats and wheat whereas around Ziway, maize realized the highest crop residue yield followed by wheat and barley. In general, straw yields increased with higher grain yields in both study areas.

Table 5 Grain and crop residue yield (t ha^{-1}) for common field crops grown in Debre Birhan of the Highland and Ziway of Central Rift Valley production system

Crop types	Study sites				Grain yield	Straw yield
	Debre Birhan				Overall	Overall
	Small herd size		Medium herd size			
	Grain	Straw	Grain	Straw		
Wheat	1.4±0.2	1.8±0.3	1.5±0.2	2.1±0.3	1.5±0.2	2.0±0.2
Barley	2.2±0.2	2.9±0.3	1.5±0.1	2.0±0.1	1.8±0.1	2.5±0.2
Tef	0.6±0.2	0.8±0.3	-	-	0.6±0.2	0.8±0.3
Field pea	1.8±0.7	1.9±0.8	0.5±0.0	0.6±0.0	1.5±0.6	1.6±0.6
Faba bean	1.9±0.4	2.1±0.4	1.1±0.3	1.2±0.3	1.6±0.3	1.7±0.3
Oats	1.6±0.3	2.1±0.5	1.5±0.2	2.1±0.2	1.6±0.2	2.1±0.2
	Ziway					
Wheat					1.5±0.1	2.7±0.2
Barley					1.3±0.0	1.8±0.1
Tef					0.7±0.0	0.9±0.1
Maize					1.9±0.2	3.5±0.3
Haricot bean					0.8±0.1	2.0±0.2

4.1.4. Livestock population, herd structure and purpose of livestock rearing

About 95% of the interviewed dairy farmers in the Highland production system possessed crossbred cattle (Table 6). Only few local cattle breed (purchased oxen) were kept by the respondents in this system. On the other hand, almost all cattle breeds in CRV (Ziway) area were indigenous breed types. Dairy farmers in the Highland study sites had comparatively better access to get inputs such as crossbred animals and commercial feeds. In addition, these farmers had more experience in raising crossbred cattle than those livestock owners involved in crossbred animal rearing at CRV (Ziway) area.

In the Central Rift Valley (CRV) area, a larger number of herds were kept to maintain draught oxen related to the larger cropland. In addition, due to risks and uncertainties of crop agriculture associated with drought and other factors, farmers in the CRV always keep large number of indigenous livestock species. In the Highland system, crop area is small because of the limited land available. In Debre Birhan crossbred male cattle were maintained within the herd for traction. Crossbred male calves were immediately culled out at Jimma and Sebeta to reduce cost of production. Income generation with milk production is the primary objective for having crossbred animals in Highland system.

Table 6 Percentage of respondents keeping crossbred and local cattle breeds and years of experience with crossbreds in the Highland and Central Rift Valley

Production system	Cattle breed		Years of experience with crossbred cattle		
	Crossbred	Local bred	2 to 5 years	Last 10 years	Over 10 years
Highland					
DB	20 (90.9%)	2 (9.1%)	2 (10%)	10 (50%)	8 (40%)
Jimma	20 (95.2%)	1 (4.8%)	8 (40%)	7 (35%)	5 (25%)
Sebeta	20 (100.0%)	-	7 (35%)	2 (10%)	11 (55%)
Total	**60 (95.4%)**	**3 (4.6%)**	**17 (28.3%)**	**19 (31.7%)**	**24 (40%)**
CRV					
Ziway	2 (3.2%)	60 (96.8%)	2 (3.3%)	-	-

DB= Debre Birhan, Figures outside of the bracket indicate number of respondents.

In the Central Rift Valley, livestock were mainly held to satisfy both milk and traction needs (Table 7). About 62 and 50% of the farmers in the Highland system held livestock for milk and dung cake production respectively. All farmers at Debre Birhan keep cattle for both traction and milk purposes while at Jimma and Sebeta dairy farmers keep cattle only for milk production. Animal dung around Ziway was used to fertilize croplands and few farmers used it for their grazing lands. Dairy farmers from Debre Birhan and Sebeta used dung mostly to make dung cake to sale at the local market or for satisfying family's own energy needs. However, in Jimma, dairy farmers considered dung as a waste and did not use it in a productive way. This resulted in complaints of neighboring community and urban municipalities on pollution of the surrounding due to bad odor. In general, the extension service in Jimma seems not effective to educate and train dairy farmers in the proper use or disposal of dung.

Table 7 Purpose of livestock keeping in the Highland and Central Rift Valley production systems

Study sites	Purpose of keeping cattle				Manure			
	Both traction and milk (%)		Milk production only (%)		As fertilizer (%)		As dung cake (%)	
	Yes	No	Yes	No	Yes	No	Yes	No
Highland								
DB (n=20)	100	-	-	100	100	-	100	-
Jimma (n=20)	5	95	95	5	5	95	-	100
Sebeta (n=20)	10	90	90	10	10	100	50	50
Total (n=60)	**38.3**	**61.7**	**61.7**	**38.3**	**38.3**	**61.7**	**50.0**	**50.0**
CRV								
Ziway (n=60)	100	-	-	100	100	-		100

DB= Debre Birhan, n= number of respondents, CRV= Central Rift Valley

The average number of livestock holding per household for the study site is shown in Table 8. The average livestock holding per household in both Highland and CRV (Ziway) was the same (15.6±0.2 TLU). Average cattle holding per household was markedly higher ($P<0.05$) for the Ziway area than Highland production system.

The average number of sheep per household was higher in the Highland system whereas the average number of goats was the higher ($P<0.05$) in the CRV. Within Highland production system, the number of sheep per household was higher ($P<0.05$) at Debre Birhan than the rest of study sites. The highest number of sheep in Debre Birhan is because of suitable weather conditions and better grazing lands. On the other hand, larger number of goats around Ziway area may be because of the better adaptation of goats to hot (lowland) conditions.

The average number of horses per household was much larger (P<0.05) in the Highland production system than Central Rift Valley. The mean number of horses was markedly (P<0.05) varied at Debre Birhan area than the rest of the study sites within the Highland system. The greater number of horses in the Highland system might be related to better adaptation to the environment and suitability of these animals for people to overcome transport problems associated with rugged terrains. At Jimma and Sebeta horses were rarely kept, but purchased from other areas for pulling carts. The average number of donkeys per household in the Central Rift Valley was higher (P<0.05) than in the Highland production system. Donkeys are mainly used for pack in the Highland system. However, in the CRV (around Ziway) donkeys are used for both pack and pulling cart. Recently and still uncommon farmers because of shortage of draught oxen, are pairing a donkey with an ox for plowing during sowing periods in Central Rift Valley system (Figure 2).

Figure 2 Pairing a donkey with an ox for plowing around Ziway

Table 8 Herd size and herd structure (Mean ±SE) per household in the Highland and Central Rift Valley production system

Livestock species	Highland				CRV	Highland (TLU)				CRV (TLU)
	DB	Jimma	Sebeta	Overall mean	Ziway	DB	Jimma	Sebeta	Overall mean	Ziway
Cattle	**11.8±0.7**	**11.9±1.5**	**8.8±1.5**	**10.8±0.7[b]**	**19.4±2.0[a]**	**14.6±0.9**	**13.3±1.7**	**11.6±1.9**	**13.2**±0.9	**12.4±1.2**
Cows	3.7±0.3	5.0±0.7	5.0±0.7	4.6±0.4	5.8±0.6	6.6±0.6	9.0±1.3	9.0±1.3	8.2±0.6[a]	4.6±0.5[b]
Oxen	2.8±0.3[x]	0.2±0.1[y]	0.6±0.3[y]	1.2±0.2[b]	3.8±0.4[a]	4.2±0.5	0.2±0.1	0.7±0.3	1.7±0.3[b]	4.2±0.4[a]
Heifers	1.5±0.3	3.1±0.6	1.7±0.4	2.1±0.3	3.2±0.5	1.0±0.2	2.1±0.4	1.2±0.3	1.4±0.2	1.6±0.2
Bulls	1.0±0.2[x]	0.7±0.2[x]	0.1±0.1[y]	0.6±0.1	0.8±0.1	1.6±0.4	0.8±0.2	0.2±0.1	0.9±0.2	0.8±0.1
Calves	3.0±0.3	3.0±0.5	1.4±0.3	2.4±0.2[b]	5.9±0.8[a]	1.2±0.1	1.2±0.2	0.6±0.1	1.0±0.1	1.2±0.2
Sheep	24.2±2.9[x]	0.7±0.6[y]	2.7±0.8[y]	9.2±1.7	5.2±1.6	2.4±0.3	0.1±0.0	0.3±0.1	0.9±0.2	0.5±0.2
Goats	0.7±0.5	-	0.4±0.3	0.3±0.2[b]	12.7±2.3[a]	0.1±0.0	-	0.1±0.0	0.1±0.0[b]	1.3±0.2[a]
Horses	1.9±0.3[x]	1.1±0.2[y]	0.1±0.0[z]	1.0±0.2[a]	0.1±0.0[b]	1.5±0.2	0.8±0.2	0.1±0.0	0.8±0.1[a]	0.1±0.0[b]
Donkeys	3.1±0.3[x]	-	1.0±0.26[y]	1.4±0.2[b]	2.8±0.5[a]	1.5±0.1	-	0.5±0.1	1.0±0.1[b]	1.4±0.2[a]
Total herd size						**20.1±0.3**	**14.3±0.4**	**12.5±0.3**	**15.6**±0.2	**15.6±0.2**

[a-b] means with different letters of superscripts in the same row differ significantly (P<0.05), [x-z] means with different letters of superscripts in the same row differ significantly (P<0.05), TLU= Tropical Livestock Unit. DB= Debre Birhan, CRV= Central Rift Valley.

4.1.5. Gender labor division for livestock related activities

Milking was commonly done twice a day in the morning and evening in both Highland and Central Rift Valley production systems. In general milking was always done by females in CRV (around Ziway) while in the Highland system (Jimma and Sebeta) in only 15% of the cases (Figure 3). In Debre Birhan, this activity was well divided among both sexes. In Debre Birhan and Ziway areas, more than half of both males and females took care of pregnant cows whereas in Jimma and Sebeta about half of the males were involved.

Cattle herding was common in Debre Birhan and Ziway areas. In contrary, in Jimma and Sebeta all herds were confined in a house. As shown in Figure 3, 65% of cattle herding activity was undertaken by males in both Debre Birhan and Ziway areas. The frequency of cleaning animals' barn varies from area to area and type of production system. Subsequently, barn cleaning was largely done by females in Debre Birhan while in Jimma and Sebeta it was mainly a task of males. On the other hand, this activity was mostly undertaken by both sexes around Ziway area. Larger proportion of females involved in barn cleaning at Debre Birhan could be because of less attention was given by males as a result of different on-farm activities. In Jimma and Sebeta areas, dairying was run by hired labor of male sex.

Herd feeding was mainly carried out by both sexes at Debre Birhan, but at Sebeta and Jimma, it was by male sex (Figure 3). Similarly, in all study areas feed collection activities such as collection of hay, crop residue and purchase of feeds were exclusively the task of males. Milk selling was in most cases performed by males in Jimma and Sebeta and it was as a whole a job of females around Ziway area. Both sexes were largely involved in milk selling activity at Debre Birhan.

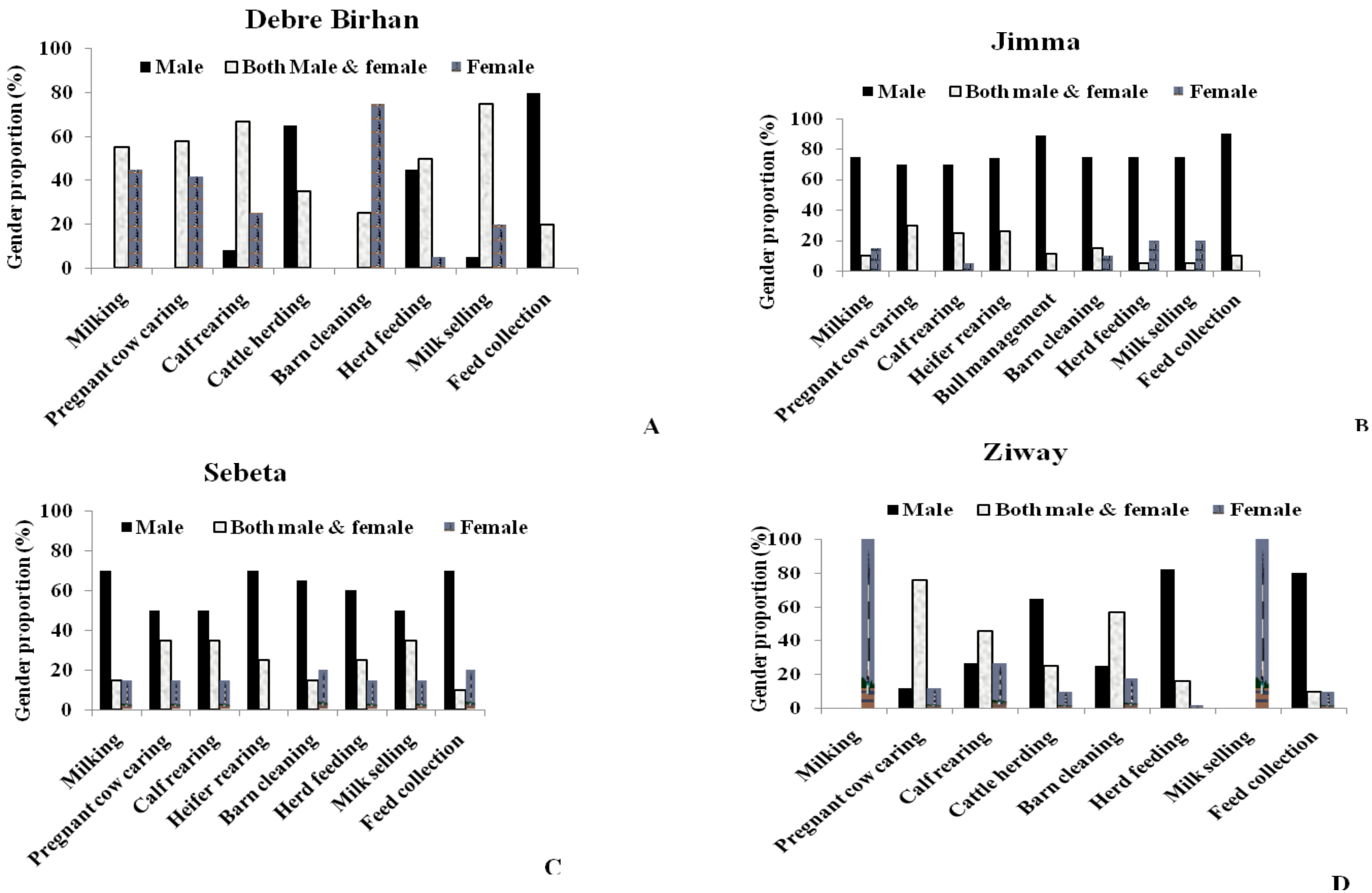


Figure 3 Participation of males and females in livestock activities

4.1.6. Animal housing

House types that were used to keep livestock during the nighttime are presented in Table 9. In the Highland production system animal houses were mostly concrete floor types with roofs while in the Central Rift valley (Ziway) animal houses were of the type kraal. Animal houses with concrete floor and roofs accounted for 75 % and 100% of the houses types in Jimma and Sebeta, respectively. In Debre Birhan, the houses were built with a stone floor and roof.

Table 9 Animal houses types used in the Highland study sites and Central Rift Valley (as % of respondents)

House types	Highland			CRV
	DB	Jimma	Sebeta	Ziway
Concrete floor with roof	-	15 (75%)	20 (100%)	-
Stone floor with roof	20 (100%)	2 (10%)	-	-
Mud floor with roof	-	1 (5%)	-	-
Both mud and wooden floor with roof	-	1 (5%)	-	-
Wooden floor with roof	-	1 (5%)	-	-
Kraal	-	-	-	60 (100%)

DB= Debre Birhan, CRV=Central Rift Valley, Figures outside of the bracket indicate number of respondents.

4.1.7. Watering management

Main sources of water in Highland production system (Debere Birhan, Jimma and Sebeta) were river and tap water (Table 10). In Jimma and Sebeta, the main source of water for cattle was tap water, while in Debre Birhan water for cattle was obtained from rivers (95%).

Table 10 Major sources of water for livestock in the Highland production system

Highland study sites	Water sources			
	River	Pond	Spring water	Tap water
Debre Birhan	19 (95%)	-	1 (5%)	-
Jimma	5 (25%)	1 (5%)	-	14 (70%)
Sebeta	-	-	-	20 (100%)
Total	**24 (40%)**	**1 (1.7%)**	**1 (1.7%)**	**34 (56.7%)**

Figures outside of the bracket indicate number of respondents.

In the Central Rift Valley, around Ziway there were various sources of water for cattle (Table 11). Almost half of the interviewed livestock farmers in this area got water for livestock from the lake (Lake Ziway) followed by combination of lake and river (22%). Despite the smaller contribution of other water sources, water shortage is the major constraint in the dry season for peasant associations (PAs) situated far away from the Lake Ziway and main rivers. Based on personal observation, herders in these areas traveled long distances with their cattle for 9 to 12 hours a day in every other day to reach to the watering points. Sometimes, conflict aggravated in the border areas between Guraghie and Oromo tribes for the use of water from rivers. As a result, robbing cattle was common as it was reported by the respondents during the interview period.

Table 11 Water sources for cattle in Central Rift Valley (Ziway)

Water sources	n	Percent (%) of respondents
River only	3	5.0
River, pond and lake	2	3.3
River, spring and lake	1	1.7
River and tap water	1	1.7
River and lake	13	21.7
Pond only	2	3.3
Pond and lake	4	6.7
Tap water only	4	6.7
Tap water and lake	1	1.7
Lake only	29	48.3
Total	**60**	**100**

n=number of respondents

As indicated in Table 12, in the Highland production system (Debre Birhan, Jimma and Sebeta) water is available close to farms and dairy farmers did not trek their animals to distant areas. However, around Ziway area, about 54 and 22% of the respondents indicated that animals traveled to get water for a distance of up to 5 and more than 10 km far, respectively. Trekking to a longer distance could probably have exacerbated weight loss of animals. A similar report by Girma *et al*. (2009) indicated that animals consume less water if they have to travel further to the source. Moreover, trekking animals with the same route frequently for water was resulted in environmental degradation in some areas around Lake Ziway as shown in Figure 4.

Table 12 The proportion (%) of livestock owners travelling with their animals to different distances of watering points in the Highlands and Central Rift Valley

Production system	Distance category				
	Watered at home	<1 km	1-5 km	6-10 km	>10 km
Highland					
Debre Birhan (n=20)	5.0	75.0	20.0	-	-
Jimma (n=20)	95.0	5.0	-	-	-
Sebeta (n=20)	100.0	-	-	-	-
Total (n=60)	**66.7**	**26.7**	**6.7**	**-**	**-**
CRV					
Ziway (n=60)	5.1	6.8	54.2	11.9	22.0

n= number of respondents

Figure 4 Degraded land following livestock trekking for water around the Lakeshore of Ziway

Watering frequency for livestock species during the dry season in the Highlands and Central Rift Valley is indicated in Table 13. In the Highland production system (Debre Birhan, Jimma and Sebeta), dairy farmers mostly provide water twice a day for cattle and equines, whereas shoats once a day. However, in CRV (around Ziway), 47, 22 and 47% of the interviewed respondents watered cattle, small ruminants and equines once in two days, respectively. Of all respondents 10, 35 and 12% in Debre Birhan, Jimma and around Ziway, respectively, were able to provide water *adlibtum*. In general, watering frequency decreased as the distance to water accessing point increased and vice versa (Kassahun *et al*., 2008).

Table 13 Watering frequency for livestock species during the dry season in the Highlands and Central Rift Valley.

Livestock species	Watering frequency	Highland				CRV
		DB n=20	Jimma n=20	Sebeta n=20	Total n=60	Ziway n=60
Cattle	*Adlibtum*	2 (10%)	7 (35%)	-	9 (15%)	8 (13%)
	Twice a day	15 (75%)	5 (25%)	12 (60%)	32 (53%)	3 (5%)
	Once a day	3 (15%)	8 (40%)	8 (40%)	19 (32%)	21 (35%)
	Once in two days	-	-	-	-	28 (47%)
Shoats	*Adlibtum*	-	10 (50%)	-	10 (16%)	7 (12%)
	Twice a day	5 (25%)	-	14 (70%)	19 (32%)	4 (6%)
	Once a day	12 (60%)	10 (50)	6 (30%)	28 (47%)	23 (38%)
	Once in two days	3 (15%)	-	-	3 (5%)	13 (22%)
	Once in three days	-	-	-	-	13 (22%)
Equines	*Adlibtum*	-	7 (35%)	-	7 (12%)	7 (12%)
	Twice a day	16 (80%)	3 (15%)	14 (70%)	33 (55%)	3 (5%)
	Once a day	4 (20%)	10 (50%)	6 (30%)	20 (33)	22 (36%)
	Once in two days	-	-	-	-	28 (47%)

n= number of respondents, Figures outside the bracket indicate number of respondents

4.1.8. Constraints of livestock production in Central Rift Valley (Ziway)

According to the survey result feed was the major problem identified constraining livestock production in the Central Rift Valley. Fifty percent (n=30) of the respondents reported feed shortage due to encroachment of grazing lands and 42% (n=25) reported lack of capital to buy feed. Based on the output of focused group discussion, feed shortage, water scarcity during the dry season, low production and productive performance of local breed animals, animal diseases and soil degradation were the major challenges in a decreasing order for livestock production and productivity in Central Rift Valley (Table 14).

Table 14 Major problems constraining livestock production in Central Rift Valley (Ziway).

Major constraints n=20	Priority levels					Rank
	1	2	3	4	5	
Feed shortage	18 (90%)	1 (5%)	1 (5%)	-	-	1
Water scarcity in dry season	3 (15%)	14 (70%)	2 (10%)	1 (5%)	-	2
Low performance of indigenous animals	4 (20%)	3 (15%)	11 (55%)	1 (5%)	1(5%)	3
Livestock diseases	2 (10%)	3 (15%)	2 (10%)	10 (50 %)	3 (15%)	4
Land degradation	5 (25%)	2 (10%)	2 (10%)	3 (15%)	8 (40%)	5

Numbers in the brackets indicate the proportion of participants, n= total number of participants.

Ninety percent of the participants in the group discussion indicated feed shortage as the major constraint for livestock production (Table 14). Land shortage for fodder production due to expansion of crop cultivation even to marginal lands was the major reason. It has been observed that recently small to large scale investors compete for land along Lake Ziway for irrigation. As a result, only few lands often of marginal type are left for grazing. It was indicated during the group discussion that the quality and productivity of natural pastures is very poor to meet the nutrient requirement of animals. Though crop residues were used to augment feed supply, it is poorly utilized due to in appropriate storage and handling practices. In addition, feed availability is further decreased due to alternative use of indigenous fodder trees and crop residues particularly maize stover as a fuel for cooking purposes. Prolonged dry period and uneven distribution of rainfall particularly in lowland agro-ecological setup such as Central Rift Valley affected crop production and re-growth of grasses. The availability of improved forage seeds is low and extension service rendered to this regard was almost negligible in the study area. Lack of available commercial feeds in the local market was also pointed out as additional problem.

According to the participants' opinion, clear land use and management policies need to be implemented and enforced through administrative bodies. Introduction of alternative energy sources, consolidated extension service on crop residue storage and efficient utilization, establishment and management practices of improved forages and soliciting technical interventions to improve the existing grazing lands were some of the recommendations of the participants.

Seventy percent of the participants ranked water as a second major problem for livestock production (Table 14). For most areas far away from Lake Ziway and permanent rivers, water supply was crucial for animal survival during dry periods. Moving cattle to distant places to look for drinking water took much time and tiresome work. Besides the risk of siltation to Lake Ziway, participants also pointed out that the declining water volume of Lake Ziway is related to increasing use of water by other stakeholders. Livestock farmers are afraid that Lake Ziway will be depleted gradually because of the increasing claims on its water.

Participants recommended, use of different water harvesting techniques to harvest runoff in the wet season in order to partly solve the problem. Water harvesting structures like deep wells and bunds and others need to be constructed with support of the government, NGOs and the community. Concerning the risks that Lake Ziway faces, participants recommended an integrated approach involving the participation of all development actors.

Low productive and reproductive performance of local animals was the third major problem prioritized by 55% of the participants (Table 14). It was emphasized that indigenous animal breeds of the area are generally characterized by small in size, low milk yield, slow growth rate and remain unproductive for a long period. The amount of milk obtained per day per cow was not more than a litter, which is insufficient to satisfy family consumption. Uncontrolled mating system, prevalent in the area, coupled with feed shortage was reported as one of the contributing factor for low productivity of the animals. Moreover, keeping large number of animals in the past was considered as an indicator of wealth but presently participants claimed only counting numbers of heads regardless of production and productivity of livestock. In some areas NGOs distributed indigenous Borana heifers among selected herders with the objective of increasing milk yield. Unfortunately, most heifers were died due to their poor adaptation to the prevailing environmental conditions. Further artificial insemination (AI) service was not introduced in the study area except around towns.

Participants of the group discussion recommended to focus first on using selected indigenous cattle germplasm together with adequate supply of inputs like feed, vet services might help to improve productivity of indigenous stock. Increasing AI service coverage and crossbreeding with exotic genotype under close supervision would further contribute to resolving the problems.

Animal disease was the fourth constraint prioritized by 50% of the participants (Table 14). Prevalent diseases described by participants include the following: Anthrax (local name: *Aba Senga)*, Foot and Mouth Disease (FMD) (local name: *Manse)* pasteurollosis (local name: *Gororsisa),* Blackleg (local name: *Aba Gorba*) and Mastitis (local name: *Mucha Ditese*). It was reported that these diseases mostly occur during the short rainy season (March to May), when the condition of animals is poor due to inadequate feed availability in the preceding dry period. Ectoparsite infestation was also reported to be high in the wet season of the year. Veterinary drugs were not commonly used, rather traditional medications extracted from herbs and trees were used to heal sick animals. It was recommended that efficient health extension service should be in place in each peasant association in order to overcome animal health problems.

The participants described that carrying capacity of their grazing land is low in relation to the number of animals kept on it. Because of this in balance, grasses are overgrazed and little groundcover is left, which favors soil erosion. Destocking as a strategy to regenerate vegetations was not acceptable for the participants. Because of the many crop failures in relation with unreliable rainfall in the area, livestock are considered as a life-saving strategy to overcome such periods. During the main rainy season (July and August) over flow of Meki river floods to adjacent grazing areas. Following the flood, there was expansion of alien invasive weeds such as Congress weed (Parthenium) on the farmers' grazing pastures in some peasant associations. Apparently, Parthenium seeds have been transported from upper catchments. Deforestation in the past, overgrazing and in appropriate farming practices such as plowing to marginal areas were described as additional causes of soil erosion.

Farmers recommended suitable soil and water conservation measures. Further, land degradation as a result of overgrazing should be overcome with the use of promising and well adapted forage species together with increasing productivity of the existing grazing lands. Creating off-farm employment opportunities could also contribute to curb the pressure on land.

4.1.9. Major constraints to feed supply and season of feed shortage in the Highland system

Based on the survey result, major problems contributed to feed shortage in the Highland study areas are indicated in Table 15. In Debre Birhan, 60 and 40 % of the dairy farmers described that grazing lands are converted into croplands and expensive market price of concentrate feeds, respectively, as the main problems of feed supply. Fifteen percent of the respondents at Debre Birhan reported that crop harvest was failed due to bad weather such as frost and ice. As a result, it is expected that the crop residues to be employed for livestock declined. Seventy five percent of both farms with small and medium herd size at Jimma and Sebeta had feed problems in relation with the current escalating cost of feeds. More over 80 and 55% of the dairy farmers at Jimma and Sebeta, respectively, indicated that commercial feeds are not available sufficiently in the market. In addition, 70% of the dairy farmers in Jimma and 85% in Sebeta did not have any land to grow forages.

Table 15 Causes of insufficient feed availability for farmers with medium and small herd sizes in the Highland study sites

Major reasons	Debre Birhan			Jimma			Sebeta			**Overall total**
	MH n=10	SM n=10	**Total n=20**	MH n=10	SM n=10	**Total n=20**	MH n=10	SM n=10	**Total n=20**	**n=60**
Encroachment of crop agriculture	50%	70%	**60%**	-	-	**-**		-	**-**	**20%**
Lack of capital (expensive market cost of feeds)	40%	40%	**40%**	80%	70%	**75%**	70%	80%	**75%**	**63%**
No sufficient quantity of commercial feed in nearby markets	-	-	**-**	80%	80%	**80%**	30%	80%	**55%**	**45%**
Over grazing	-	10%	**5%**		-	**-**		-	**-**	**2%**
No land to grow feed	-	-	**-**	80%	60%	**70%**	90%	80%	**85%**	**52%**
Damage of crops by bad weather	20%	10%	**15%**	-	-	**-**	-	-		**5%**

MH= Medium herd size, SH= Small herd size, n= Number of respondents

Season of feed shortage for the Highland peri-urban study sites is shown in Table 16. In Debre Birhan and Jimma, 65% and 80% of the respondents encountered feed shortage in wet and dry seasons, respectively. Among the farmers with small herd sizes, 90% in Debre Birhan and 40% in Sebeta did not have enough feed in wet seasons. All farmers with medium herd sizes in Jimma while 60% of them in both Debre Birhan and Sebeta encountered feed shortage in the dry season. In general, feed shortage is more severe in all study areas in dry season than wet season.

Table 16 Feed shortage seasons drawn from the interviewed respondents (%) in the Highland production system

Study sites	Herd size category	Seasons of feed shortage			
		Dry (January to May)	Wet(July to August)	Both wet and dry	All year round
Debre Birhan	Small (n=10)	10%	90%	-	-
	Medium (n=10)	60%	40%	-	-
	Subtotal (n=20)	**35%**	**65%**	**-**	**-**
Jimma	Small (n=10)	60%	10%	20%	10%
	Medium (n=10)	100%	-	-	-
	Subtotal (n=20)	**80%**	**5%**	**10%**	**5%**
Sebeta	Small (n=10)	60%	40%	-	-
	Medium (n=10)	60%	30%	10%	-
	Subtotal (n=20)	**60%**	**35%**	**5%**	
	Total (n=60)	**58%**	**35%**	**5%**	**2%**

n= number of respondents

4.1.10. Consequence of feed shortage on the performance of livestock

Consequences of feed shortage on livestock production and productivity based on the respondents response is presented in Table 17. The consequences of feed shortage for livestock in all study areas include weight loss, lower milk yield, mortality and absence of heat. About 92% of the respondents around Ziway indicated weight loss and reduced milk yield, while mortality due to feed shortage was reported by 43% of the respondents. In Debre Birhan, Jimma and Sebeta, farmers reported weight loss and low milk yield as the major consequences of feed shortage. On the other hand, 20 and 30% of the dairy farmers in these areas indicated absence of behavioral heat standings as the major consequence of feed shortage. Ten and fifteen percent of the respondents in Jimma and Debre Birhan, respectively, reported cattle mortality as a result of feed shortage.

Table 17 Consequence of feed shortage on livestock performance in the Highlands and Central Rift Valley production system

Production system	Herd size category	Weight loss	Low milk yield	Mortality	No signs of estrus
Highland					
DB	Small (n=10)	8(80%)	8(80%)	3(30%)	-
	Medium (n=10)	7(70%)	7(70%)	-	1(10%)
	Subtotal (n=20)	**15(75%)**	**15(75%)**	**3(15%)**	**1(5%)**
Jimma	Small (n=10)	10(100%)	10(100%)	2(20%)	3(30%)
	Medium (n=10)	9(90%)	9(90%)	-	1(10%)
	Subtotal (n=20)	**19(95%)**	**19(95%)**	**1(10%)**	**4(20%)**
Sebeta	Small (n=10)	9(90%)	9(90%)	-	3(30%)
	Medium (n=10)	9(90%)	9(90%)	1(10%)	3(30%)
	Subtotal (n=20)	**18(90%)**	**18(90%)**	**1(5%)**	**6(30%)**
	Total (n=60)	**52(87%)**	**52(87%)**	**5(8%)**	**11(18%)**
CRV					
Ziway		55(92%)	55(92%)	26(43%)	8(13%)

DB=Debre Birhan, CRV=Central Rift Valley, numbers in the bracket indicate proportion of respondents, n= total number of respondents

4.1.11. Ways of feed shortage alleviation

During critical feed shortage seasons, livestock owners in all study areas use different strategies to alleviate the problem. Accordingly, during the dry periods, 85% of the farmers around Ziway use farm produced crop residues to feed animals while in the wet season (July to August), 43% of them use rented grazing pasturelands in other areas (Table 18). In Jimma and Sebeta almost all dairy farmers depend on purchased supplement feeds. In addition to supplement feeds, dairy farmers in Debre Birhan and Sebeta relied on crop residues. Non-conventional feeds such as *Atela*, pulse hulls and papaya stem were not available at large in all study areas and their contribution to livestock feed as a cooping strategy was small.

Table 18 Different coping mechanisms used to alleviate feed shortage in all study areas as per the interview

Production system	Herd size	Interventions					
		Purchase supplement feeds	Rented grazing lands	Purchase crop residue	Using farm produced crop residue	Destocking	Using non-conventional feeds (A*tela*, pulse hulls and papaya stem)
Highland							
DB	Small (n=10)	6(60%)	5(50%)	1(10%)	7(70%)	2(20%)	-
	Medium (n=10)	7(70%)	7(70%)	-	7(70%)	2(20%)	-
	Subtotal (n=20)	**13(65%)**	**12(60%)**	**1(5%)**	**14(70%)**	**4(20%)**	
Jimma	Small (n=10)	10(100%)	-	-	-	1(10%)	1(10%)
	Medium (n=10)	8(80%)	-	-	-	1(10%)	-
	Subtotal (n=20)	**18 (90%)**	**-**	**-**	**-**	**1(5%)**	**1(5%)**
Sebeta	Small (n=10)	10(100%)	-	8(80%)	-	-	-
	Medium (n=10)	9(90%)	-	7(70%)	-	-	-
	Subtotal (n=20)	**19(95%)**		**15(75%)**	**-**	**-**	**-**
	Total (n=60)	**50(83%)**	**12(20%)**	**16(27%)**	**14(23%)**	**5(8%)**	**2(3%)**
CRV							
Ziway (n=60)		2(3)	26(43%)	-	51(85%)	4(7%)	2(3%)

DB=Debre Birhan, n= Total number of respondents, Numbers in the bracket indicate proportion of respondents.

4.2. Productive and Reproductive Performance of Cattle in the Highland and Central Rift Valley Production System

4.2.1. Daily milk yield

The estimated mean daily milk yield based on the farmers response varied significantly (P<0.001) among the Highland study sites (Table 19). In Sebeta, the estimated daily milk yield (9.7±0.5 kg) was higher (P<0.001) than the rest of the study areas. The range of observed daily milk yields (6.1 to 9.7 kg) in Highland study sites corresponds well with values reported earlier (Demeke *et al*., 2000). The current report also agreed with what Mesfin *et al*. (2009) reported for crossbred dairy cows in North Shoa and Mulugeta *et al*. (2009) in the Yerer watershed, Oromia region. Yoseph *et al*. (2003b) reported for crossbred dairy cows an average daily milk yield of (8.9 kg/day) at Sebeta and Kaliti, which is closer to the current finding. However, Moges and Baars (1998) reported slightly higher average milk yields (9-12 kg/day) at Alemaya University. The difference could be attributed to differences in management conditions and the level of exotic gene inheritance in the crossbred animals.

Unlike the Highland system, the dominant cattle breed adapted in the Ziway area are indigenous Arsi breed, which are characterized by low milk yield and small size. The overall estimated daily milk yield from Arsi breed in the Ziway area was about (1.5±0.3 kg/day), excluding the milk suckled by the calf (Table 20). Milk yield was significantly varied (P<0.05) among peasant associations (PAs) in this area. The higher milk yield was observed at Belekle Grisa followed by Negalign PA. The relatively higher milk yield observed in the two areas could be associated to better feed supply since the two sites are closer to towns and irrigation to purchase concentrate feed and grow fodder. The overall yield in Ziway area is a bit higher than the value reported by Lemma *et al*. (2005) in same area. In the other areas of the country, a mean daily milk yield of 1 kg/day (Kedija, 2007) and 1.2 kg/day (Mulugeta *et al*., 2009) was reported for local cows. However, the observed value in the current study is lower than the estimated daily milk yield in agro-pastoral areas of southern Ethiopia (Adugna and Aster, 2007). It might be related to feed shortage encountered due to prolonged drought during the study period. Moreover, indigenous breeds of cattle are low yielders under poor management conditions (Million and Tadelle, 2003).

There was marked difference in estimated daily milk yield between farms with small and medium herd sizes in Sebeta area (P<0.05). The highest estimated daily milk yield observed for farms with medium herd sizes in Sebeta area could possibly be the result of better access to brewery by- products, agro-industrial by-products and hay. In addition, dairy farmers at Sebeta have relatively better access to high graded cattle from Addis Ababa and commercially-oriented large-scale dairy farms in the surroundings. The current finding is in close agreement with the work of Yoseph *et al*. (2003b) who reported mean daily milk yield varied from 5.9 to 10 kg in urban and peri-urban dairy production systems in the Addis Ababa milk shed.

4.2.2. Lactation length

The overall estimated mean lactation length of cows in the Highland system was 296 days (Table 19) and was not different (P>0.05) among sites. The estimated lactation length was comparable to the ideal lactation length of 305 days as defined by Foley *et al*. (1972). The effect of study site and herd size on lactation length was not significant (P>0.05). The overall estimated mean lactation length was 296 days and varied from 273 to 327 days.

The overall estimated lactation length (321 days) around Ziway was slightly longer (Table 20), but comparable with reported lactation lengths of 330 and 315 days for local breeds by Fekadu (1994) and Lemma *et al*. (2005), respectively. Lactation length was not different (P>0.05) among PAs. Farmers have the attitude that extended length of lactation favors growth of calves despite low milk yields.

4.2.3. Age at first service and calving

The overall estimated mean age of heifers at first service was 27.5 months and age at first calving was 36.8 months and differed (P<0.001) considerably among the Highland study sites. Estimated mean ages of heifers at first service and calving were shortest at Sebeta (24.3 and 33.6 months) compared to other sites. The results are in accordance with the mean value of 25.6 months reported for age at first service and 36.2 months reported for age at first calving for dairy heifers under urban production systems (Emebet, 2006). Heifers maturing at younger ages are better milk producers and have lower rearing costs (Ruiz-Sanchez *et al*., 2007).

The overall estimated mean ages at first service and calving for heifers around Ziway (Table 20) were slightly higher than what has been reported for Borana breeds in Southern Ethiopia (Adugna and Aster, 2007) but close to those reported for Horro cattle in West Wallaga Ethiopia (Alganesh *et al*., 2004). The longer age at first service and calving in Ziway area might reflect later maturity. Improved management levels such as good nutrition, housing and health care enhances growth rate of heifers to come on first heat at early age.

Estimated mean ages at first mating and calving were significantly ($P<0.05$) longer for dairy farms with small herd sizes in Debre Birhan. While estimated mean ages at first mating and calving were shorter (23.5 and 32.9 months) for farms with medium herd sizes at Sebeta. The age at first calving estimated from this area did not agree with the estimated mean of 30.1 months by Kelay (2002). The difference could be attributed to differences in level of management between small and medium holders. Neither the age at first service nor the age at first calving in the present work meet the optimum age at first service and calving i.e. 14.6 and 24 months for milk yield as reported by Nilforooshan and Edriss (2004).

4.2.4. Calving interval and days open

The overall estimated mean calving interval and days open in the Highland system were about 471.5 and 191.5 days, respectively (Table 19). There was no difference ($P>0.05$) in length of calving interval and days open among the Highland study sites (Table 19). The length of days open was a bit more than 6 months in all Highland study sites, which might affect the profitability of dairy cows. De Vries (2006) concluded that a decrease in the days open from 166 to 112 days would significantly increase pregnancy rates, profit per cow and decrease breeding and labor cost.

Table 19 Least square means (LSM ±SE) milk production and reproductive performance of crossbred dairy cows in the Highland production system by herd size.

Variables	Herd size	Study sites			
		DB	Jimma	Sebeta	Overall means
MY (kg/day)	Smallholder	5.3±0.7	6.4±0.7^{b}	8.7±0.7^{ya}	6.8±0.5^{y}
	Medium holder	6.8±0.7	7.8±0.7^{b}	10.7±0.7^{xa}	8.4±0.5^{x}
	Mean	6.1±0.4	7.1±0.5^{b}	9.7±0.5^{a}	7.6±0.3
LL(days)	Smallholder	291.0±21.2	288.5±21.2	300.0±21.2	293.2±11.4
	Medium holder	327.0±21.2	273.0±21.2	294.0±21.2	298.0±13.0
	Mean	309±18.2	280.8±14.7	297.0±10.6	295.6±8.7
AFS (months)	Smallholder	35.1±2.3^{a}	26.1±2.3^{b}	25.0±2.3	28.7±1.6
	Medium holder	29.9±2.3	25.3±2.3	23.5±2.3	26.3±1.3
	Mean	32.5±1.7^{a}	25.7±1.4^{b}	24.3±1.7	27.5±1.0
AFC (months)	Smallholder	44.4±2.3^{a}	35.4±2.3^{b}	34.4±2.3	38.1±1.6
	Medium holder	39.2±2.3	34.7±2.3	32.9±2.3	35.6±1.3
	Mean	41.8±1.7^{a}	35.0±1.5^{b}	33.6±1.7	36.8±1.0
CI (days)	Smallholder	435.0±49.2	498.0±49.2	498.0±49.2	477.0±32.3
	Medium holder	519.0±49.2	429.0±49.2	450.0±49.2	466.0±23.2
	Mean	477.0±32.5	463.5±39.6	474.0±31.5	471.5±20.1
DO (days)	Smallholder	155.0±49.2	218.0±49.2	218.0±49.2	197.0±32.3
	Medium holder	239.0±49.2	149.0±49.2	170.0±49.2	186.0±23.2
	Mean	197.0±32.5	183.5±39.6	194.0±31.5	191.5±20.1

$^{a-b}$ means with different superscript in the same row for the same trait do significantly differ (P<0.05); $^{x-y}$ means with different superscript in the same column for the same trait do significantly differ (P<0.05). MY= Milk Yield, LL= Lactation Length, AFS= Age at First Service, AFC=Age at First Calving, CI=Calving Interval, DB=Debre Birhan, DO=Days Open.

Table 20 Least squares means (LSM ±SE) productive and reproductive performance of cows around Ziway area as per the interviews

PAs	Milk yield(kg/day)	LL (days)	AFS (months)	AFC (months)	CI (days)	DO (days)
Abine Germame	1.1±0.3[c]	280.0±33.9	49.5±5.2	58.1±5.2	630.0±87.3	350.0±87.3
Bekele Grisa	3.2±0.3[a]	335.0±33.9	46.6±5.7	56.0±5.7	586.7±87.3	306.7±87.3
Elka Chelemo	1.6±0.3[bc]	300.0±29.3	53.0±4.5	62.4±4.5	585.0±75.6	305.0±75.7
Gallo Rapee	0.9±0.3[c]	315.0±29.3	51.5±4.5	60.8±4.5	697.5±75.6	417.5±75.7
Gebiba Rasa	1.2±0.3[c]	322.5±29.3	59.1±4.5	68.4±4.5	776.3±75.6	496.3±75.6
Grabakorki Adi	0.9±0.3[c]	320.0±33.9	53.5±5.2	62.9±5.2	690.0±87.3	410.0±87.3
Negalign	2.3±0.3[b]	400.0±33.9	42.4±5.2	51.7±5.2	735.0±87.3	455.0±87.3
Wellinbula	1.5±0.3[bc]	350.0±33.9	50.5±5.2	59.8±5.2	690.0±87.3	410.0±87.3
Woldiya Mekidela	1.0±0.3[c]	270.0±33.9	49.5±5.2	58.8±5.2	540.0±87.3	260.0±87.3
Overall mean	1.5±0.3	320.5±32.3	51.1±5.0	60.4±5.0	661.7±83.4	381.7±83.4

[a-c] means in the same column followed by the same letter of superscript for a trait are not significantly different (P>0.05), PAs = Peasant Associations, LL= Lactation Length, AFS= Age at First Service, AFC=Age at First Calving, CI=Calving Interval, DO=Days Open.

4.2. 5. Mating systems

Commonly used mating systems in the study areas are indicated in Table 21. About 52 and 97% of the respondents in the Highland and Central Rift Valley production systems, respectively, use natural service. Artificial insemination (AI) service was almost absent in the CRV while 23% of the farmers in the Highland system combine AI and natural service. However, about 25% of the farmers in the Highland production system use a combination of AI and natural mating. More than half of the respondents at Sebeta had access to AI service while 75% of the respondents at Debre Birhan and Jimma use natural service. Because of technical and non-technical problems, AI has not yet been introduced at a large scale in areas which are located further away from Addis Ababa. Dairy farmers at Jimma explained that AI service has almost totally collapsed in the area since 2003 following the decentralization policy of the government. As a result, AI technicians face lack of funds to bring frozen liquid nitrogen from the central processing plants in the country. In addition, some farmers pointed out that a cow that was inseminated with AI could come in to heat repeatedly, which might be associated with time of insemination, use of proper insemination technique, semen quality and technical efficiency of AI technicians. Recently, the Oromia National Regional State government has understood the problem and established an independent livestock development agency with its own logistics and human resources.

Farmers in Debre Birhan area use crossbred bulls of any blood level. The number of farmers receiving bull service from Debre Birhan Research Center was very small. AI service has not been widespread in the area mainly because of a range of structural, service and transport problems. The present work agrees with a report of Tadesse (2005), Gibson *et al*. (2006) and Emiru (2007). It was observed that indiscriminate breeding practice is common in the area, which leads to inbreeding and genetic erosion. Around Ziway area, livestock owners living far away from Ziway town did not get AI service and cross breeding activity is almost non-existent. The relatively hot climate, critical feed shortage during dry season, animal health problem, week extension service and the nature of the production system by itself might explain the reason why crossbred animals are not predominant in the area.

Desalegn (2008) showed that the proportion of AI users was higher around Addis than in regional sites. Major constraints associated with AI in Ethiopia include loose structural linkage between AI Center and service giving units, absence of collaboration and regular communication between National Artificial Insemination Center (NAIC) and stakeholders, lack of breeding policy and herd recording system, inadequate resources in terms of inputs and facilities, and absence of incentives and rewards to motivate AI technicians (Desalegn, 2008).

Table 21 Mating systems used in the Highland and Central Rift Valley production systems

Production system	Mating system		
	AI	NS	Both AI and NS
Highland			
Debre Birhan (n=20)	2 (10.0%)	15 (75.0%)	3 (15.0%)
Jimma (n=20)	1 (5.0%)	15 (75.0%)	4 (20.0%)
Sebeta (n=20)	11 (55.0%)	1 (5.0%)	8 (40.0%)
Total (n=60)	**14 (23.3%)**	**31 (51.7%)**	**15 (25.0%)**
CRV			
Ziway (n=60)	0.0	58 (96.7%)	2 (3.3%)

n =number of respondents, AI = Artificial Insemination, NS= Natural Service, numbers in the bracket indicate proportion of respondents.

4.3. Feed Resource Availability in Highland and Central Rift Valley Production System

4.3.1. Composition of natural pasturelands around Ziway

An area closure was used as a benchmark to assess the potential biomass yield and dry matter production of grasses and herbaceous species around Ziway area. Grasses species represented 86% of the DM biomass production while forage legumes only 2% (Table 22). The higher share of grasses species agrees with Sisay (2006) and Teshome (2007). The lower proportion of legumes observed might probably be due to climbing or sprawling growth habit, which makes them more susceptible to loss through grazing in the lower altitudes. The proportion of legumes tends to increase with increasing altitude and particularly above 2,200 meters and at lower altitudes native legumes are less abundant (Alemayehu, 1985; Alemu, 1990).

Table 22 Proportion of grasses, forage legumes and forbs on DM basis from area closure around Ziway

Sample type	Proportion (%)
Grasses	86.1
Forage legumes	2.2
Other forbs	11.7
Total	**100.0**

4.3.2. Productivity of natural pastureland around Ziway

Biomass yield of grasses, forage legumes and forbs was 3597 kg ha^{-1}, 67.4 kg ha^{-1} and 298.5 kg ha^{-1}, respectively (Table 23). Dry matter yield obtained from legumes was lowest (12.7 kg ha^{-1}) while it was higher for grasses (1172.5 kg ha^{-1}). The lower yield of legumes could also be related with low proportion of legumes in the natural pasture of lowlands. This is in line with the report of Amsalu (2000) who demonstrated low dry matter yield of legumes (0-16 kg ha^{-1}) in the mid Rift Valley. The average dry matter yield of grasses in the current study agrees with the work of Amsalu (2000) who reported 1470 kg ha^{-1} for grass in the Central Rift Valley. The average dry matter yield estimated per tree and shrub was 32.6 and 0.3kg, respectively.

Table 23 Mean (±SE) biomass yield and DM production of grasses and herbaceous vegetation from an enclosure in Ziway

Sample type	Biomass yield (kg ha^{-1})	DM yield (kg ha^{-1})
Grasses	3597.0±402.4	1172.5±131.2
Forage legumes	67.4±32.5	12.7±6.1
Other forbs	298.5±93.2	48.1±15.0
Fodder trees	-	32.6 (kg tree^{-1})
Shrubs	-	0.3 (kg shrub^{-1})

As indicated in Table 24, the most valued grass species identified by herders were *Cenchrus ciliaris, Cynodon dactylon* and *Chloris gayana.* Herders perceived that animals, which graze these grass species, do have better body condition, give better milk and butter production. The availability of grasses like *Harpachne schimperi* and *Sporobouls pyramidalis* species is reported to be a characteristics for degraded areas, which were faced heavy grazing pressure.

Table 24 Dominant grass species identified in an enclosure around Ziway

Grass species	Category
Andropogon chrysostachys	Invader
Brachiaria dictyonuera	Increaser
Cenchrus ciliaris	Decreaser
Chloris gayana	Decreaser
Cynodon dactylon	Decreaser
Dactyloctenium aegyptium	Increaser
Eragrostis teniufolia	Increaser
Harpachne schimperi	Invader
Heteropogon contortus	Invader
Hyparrhenia rufa	Increaser
Pennisetum stramineum	Increaser
Sporobouls pyramidalis	Invader

Almost all browse trees were predominantly acacia species with few other fodder trees such as *Balanites aegyptica, Ziziphus mauritiana, Acanthus aroreus* (Table 25). Among the acacia species *Acacia albida* and *Acacia brevispica* were preferred in the dry season by herders as feed for goats and sometimes for cattle. Except acacia species, other indigenous browse trees have currently almost depleted from herders' land due deforestation. It was observed that in an enclosure some of the browse trees, except acacia species, are loped away by herders to feed draught oxen and milking cows in the dry periods.

Table 25 Browse trees identified in the Central Rift Valley (Ziway)

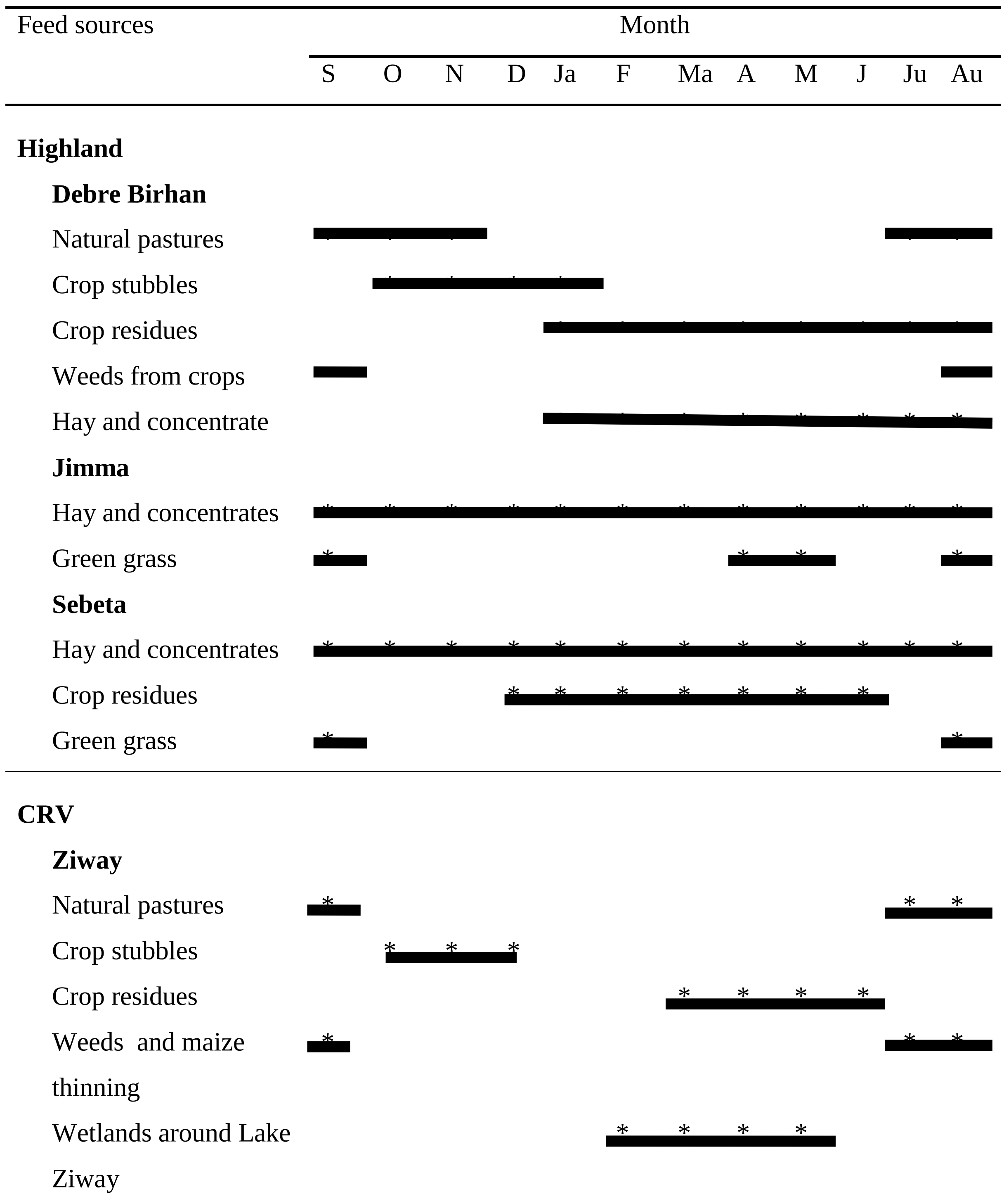
Vernacular name (Afan Oromo)	Scientific name
Dodeti	*Acacia abyssinica*
Ajoo	*Acacia albida*
Kertefa	*Acacia brevispica*
Wachu	*Acacia seyal*
Geto	*Acacia bussei*
Lafto	*Acacia dolichocephala*
Amalakaa	*Celtis africana*
Koshoshila	*Acanthus aroreus*
Kurkura	*Ziziphus mauritiana*
Bedena	*Balanites aegyptica*
Kelkelcha	*Clutia abyssinica*
Tatesa	*Rhus glutinosa*

4.3.3. Seasonal availability of feed resources in Highland and Central Rift Valley

In the Highland production system purchased hay, concentrates and crop residues were major feed resources while natural pasture and crop residues were in the Central Rift Valley system. Commonly available feed resources across the different periods of a year for the Highland and Central Rift Valley system are indicated in Figure 5. In Debre Birhan area, crop residues and hay were among the most common feeds used by both farms with medium and small herd sizes in the dry season, whereas grazing pasture and crop stubbles grazing were dominant in the wet season. Concentrates such as noug cake and wheat bran were sometimes provided to supplement the basal diet. Crop residues were also used as feed during the heavy rainy months (July to August). In Jimma and Sebeta, animals were confined in a house, as a result, hay and concentrates were the common feed resources for both medium and smallholder dairy farmers during the entire year. Green grasses were used rarely in these areas during wet and dry seasons. Purchased crop residues were also used as additional feeds for animals in the dry season at Sebeta.

In the Ziway area, natural pastures are the main feed resources from July to September. Stubbles of haricot bean, wheat, *tef*, barley and maize lands are also the major feed resources following the cessation of the main rain season (October to December). Weeds and maize thinning also contributed though not much less. In the dry period, (in most cases from January to June), crop residues like maize stover, wheat straw, *tef* straw, haricot bean straw and barley straw were the major feed resources. The wetlands around Lake Ziway were equally important with that of crop residues in this period when water level draws back.

In wet season (July to the beginning of September), 30% (n=18) of the respondents around Ziway move with their cattle to Habernosa area, where green grazing pasture is available as most farm land is used for crop production. Some farmers rented grazing pasturelands and move their cattle, together with some of the family members, to distant areas of up to one or two days journey. The practice of moving cattle together with some family members for grazing pastureland and is traditionally called as '*Godantu*'. Animals and some family members stay in the *Godantu* area from June to September. In the dry season i.e. from January to May, about 6% of the respondents around Ziway sent their cattle to relatives far away from their residence. This is because some family relatives in other areas might have relatively larger grazing pastureland and allow it to be used by their relatives free of charge. Seventy percent (n=42) of the respondents do not move their cattle to other areas and they use their own grazing lands, borderlands in between adjacent crop fields, green maize stock and weeds for feeding.



*the feed resource mentioned is available in the specified month/months. S= September, O= October, N= November, D= December, Ja= January, F= February, Ma= March, A= April, M= May, J= June, Ju= July, Au= August

Figure 5 Feed resources availability across the different months of the year

4.3.4. Crop residue preference

Crop production and crop residue are only common in Debre Birhan from the Highland system and Ziway in the CRV system. Around Ziway, barley straw was the most preferred feed by farmers followed by maize stover (Table 26). The least preference index value was for wheat straw. Farmers in this area perceived that wheat straw might cause diarrhea and emaciation in cattle. In Debre Birhan, barley was ranked first followed by faba bean straw. This is because, the area is suitable for growing barley and the soft structure of its straw facilitates palatability. Just as in Ziway area, wheat straw was less preferred by farmers in Debre Birhan for the same reasons.

Table 26 Preference indices of farmers at Debre Birhan and around Ziway for crop residues

Crop residue type	Rank					Index
	1st	2nd	3rd	4th	5th	
Ziway (n=60)						
Barley straw	35	14	8	2	1	0.28
Maize stover	18	16	17	9	-	0.24
Tef straw	3	12	19	15	11	0.18
Haricoat bean straw	1	18	9	20	12	0.17
Wheat straw	4	3	8	17	28	0.13
Debre Birhan (n=20)						
Barley straw	20	-	-	-	-	0.80
Broad bean straw	-	18	2	-	-	0.58
Field pea straw	-	17	3	-	-	0.57
Oats straw	-	3	16	1	-	0.42
Wheat straw	-	-	1	19	-	0.21

n=number of respondents, Index for Ziway: sum of single crop residue preference ranked i.e. (5*1st ranked crop residue preference) + (4*2nd ranked crop residue preference) + (3*3rd ranked crop residue preference) + (2*4th ranked crop residue preference) + (1*5th ranked crop residue preference)/sum of all weighted crop residue preference described by the respondents. Similarly Index for Debre Birhan: sum of single crop residue preference ranked i.e. (4*1st ranked crop residue preference) + (3*2nd ranked crop residue preference) + (2*3rd ranked crop residue preference) + (1*4th ranked crop residue preference)/sum of all weighted crop residue preference.

4.3. 5. Crop residue storage and utilization

Collection of crop residues follows harvesting of the grain. Crop residue storage time and form of utilization is shown in Table 27. In the highland production system, about 88% of the respondents provide crop residue soon after collection. This is probably related with few available grazing lands and the amount of hay stored may not be adequately sufficient for the animals. In the CRV about 85% of the respondents stored crop residues for more than two months before feeding to cattle. Seventy percent of the respondents mix crop residues with other feeds in the Highlands. In Debre Birhan and around Ziway, crop residues are piled in a conical shape pattern to protect them from rain and stored without shade. On the other hand, purchased crop residues at Sebeta were stored in loose or baled form under shade. About 75% of the interviewed dairy farmers at Debre Birhan and all interviewed dairy farmers in Sebeta provided crop residues to cattle soon after collection. Longer storage time of crop residues before feeding around Ziway might be related with shortage of additional feed reserves such as hay for draught oxen during plowing periods (April to June). Around Ziway, 88% of the interviewed respondents offered whole straw to animals without any chemical or physical treatment. Besides, about 52% of the respondents in the same provided threshed maize stock (which was threshed by cattle after the grain was collected) and 32% of the respondents used chopped air-dried maize stover to feed animals. About 75 and 65% of the dairy farmers in Debre Birhan and Sebeta, respectively, offered whole straw mixed with other feeds like water, salt and *atela*.

Table 27 Length of storage period of crop residues before feeding to the animal and form of feeding in Highland and Central Rift Valley

Production system	Storage time after collection				Form of feeding					
	Soon	One month	Two months	Over two months	WS	WMS	CMS	TMS	TS	MF
Highland										
DB (n=20)	15(75%)	1(5%)	-	4(20%)	16(80%)	-	-	-	4 (20%)	15(75%)
Sebeta (n=20)	20(100%)	-	-	-	6(30%)	-	-	-	-	13(65%)
Total (n=40)	**35(88%)**	**1(2%)**	**-**	**4(10%)**	**22(55%)**	-	-	-	**4(10%)**	**28(70%)**
CRV										
Ziway (n=60)	1(2%)	-	8(13%)	51(85%)	53(88%)	10(17%)	19(32%)	31(52%)	-	2(3%)

DB= Debre Birhan, WS=whole straw alone, WMS=whole maize stock without chopping or threshing, CMS= chopped air-dry maize stover, AMT= air- dry maize stover threshed by cattle TS= treated straw, MF= mixed with other feeds, N=number of respondents, Numbers in brackets indicate proportion of respondents.

4.3.6. Hay

Natural grass hay is the major feed resource for animals in the peri-urban areas. In Debre Birhan, hay was piled and stored without shade. In Jimma, hay was stored in a loose form under shade while in Sebeta it was baled and stored under shade. As shown in Table 28, 40% of the dairy farmers at Debre Birhan collected hay from their own pasturelands and another 40% were from rented pasturelands. However, 90 % of the dairy farmers in both Jimma and Sebeta did not grow hay but collect it from market.

Table 28 Sources of hay in the Highland study sites

Study sites	Sources		
	Produced at own farm (% of respondents)	Purchased (% of respondents)	Grown on rented land (% of respondents)
Debre Birhan (n=20)	40	20	40
Jimma (n=20)	-	90	10
Sebeta (n=20)	-	90	10

n= Number of respondents

4.3.7. Improved forage resources

The use of improved forages as animal feed was not well adopted by farmers in all the study areas (Table 29). In the Highland production system only 13% of the respondents grow improved forages where as the proportion for CRV was very few. About 35 % of the dairy farmers in Debre Birhan reported that they use improved forages, such as oats and vetch as animal feed. In Jimma and Sebeta, improved forages were rarely available. Only few farmers in Sebeta, who grow Napier grass at the backyard, used it as animal feed. Most farmers did not establish and utilize improved forages as animal feed.

Table 29 Proportion of respondents using improved forages in the Highlands and Central Rift Valley production system.

Production system	Herd size category	Do you use improved forages?	
Highland		Yes	No
Debre Birhan	Small (n=10)	40%	60%
	Medium (n=10	30%	70%
	Subtotal (n=20)	**35%**	**65%**
Jimma	Small (n=10)	-	100%
	Medium (n=10)	-	100%
	Subtotal (n=20)	**-**	**100%**
Sebeta	Small (n=10)	-	100%
	Medium (n=10)	10%	90%
	Subtotal (n=20)	**5%**	**95%**
	Total (n=60)	**13%**	**87%**
CRV			
Ziway (n=60)		5%	95%

n=number of respondents

The major reasons hindering development of improved forages are indicated in Table 30. Seventy two percent of the respondents in the Highland production system reported lack of land to grow improved forage as a major problem. On the other hand, in the Central Rift Valley about 78% of the respondents did not have awareness on how to establish and grow improved forages. This indicates that the extension service rendered in this area is somewhat weak.

Table 30 Major reasons hindering the development of improved forages in the Highland and Central Rift Valley production system.

Production system	Herd size	Constraints identified			
Highland		Lack of land	Lack of capital(to buy seed)	No forage seed supply	Lack of awareness
DB	SH (n=10)	2(20%)	-	1(10%)	2(20%)
	MH(n=10)	4(40%)	-	4(40%)	3(30%)
	Subtotal (n=20)	**6(30%)**	**-**	**5(25%)**	**5(25%)**
Jimma	SH (n=10)	10(100%)	2(20%)	6(60%)	2(20%)
	MH(n=10)	10(100%)	-	4(40%)	1(10%)
	Subtotal (n=20)	**20(100%)**	**2(10%)**	**10(50%)**	**3(15%)**
Sebeta	SH (n=10)	10(100%)	-	-	9(90%)
	MH(n=10)	7(70%)	-	1(10%)	4(40%)
	Subtotal (n=20)	**17(85%)**	**-**	**1(5%)**	**13(65%)**
	Total (n=60)	**43(72%)**	**4(7%)**	**16(27%)**	**21(35%)**
CRV					
Ziway	n=60	10(17%)	-	11(18%)	47(78%)

DB= Debre Birhan, n=number of respondents, numbers in the bracket indicate proportion of respondents, SH=small herd size, MH= medium herd size.

4.3.8. Use of irrigation

Since there is no farmland available at Sebeta and Jimma, irrigation was not common. Around Ziway area, the main source of water for irrigation was lake water and at Debre Birhan the main sources were rivers and springs. In the Ziway area, 17% of the farmers produced vegetables with irrigation while about 7% of the farmers produced both food crops and animal feeds (Table 31). In Debre Birhan, about 5% the dairy farmers have irrigation access to produce food crops and animal feed. In general, it was observed that most farmers who have direct access to water sources use irrigation for farming activities.

Table 31 Purpose of irrigation in the Highland and Central Rift Valley as per the interview

Production system	Herd size	Purpose of irrigation			
		Food crops	Both food crops and feed	Vegetable	Vegetable and food crops
Highland					
Debre Birhan	Small (n=10)	-	-	2(20%)	-
	Medium (n=10)	-	1(10%)	1(10%)	1(10%)
	Total (n=20)	**-**	**1(5%)**	**3(15%)**	**1(5%)**
CRV					
Ziway (n=60)		1(2%)	4(7%)	10(17%0	4(7%)

Numbers in the bracket indicate proportion of respondents, n= Total number of respondents

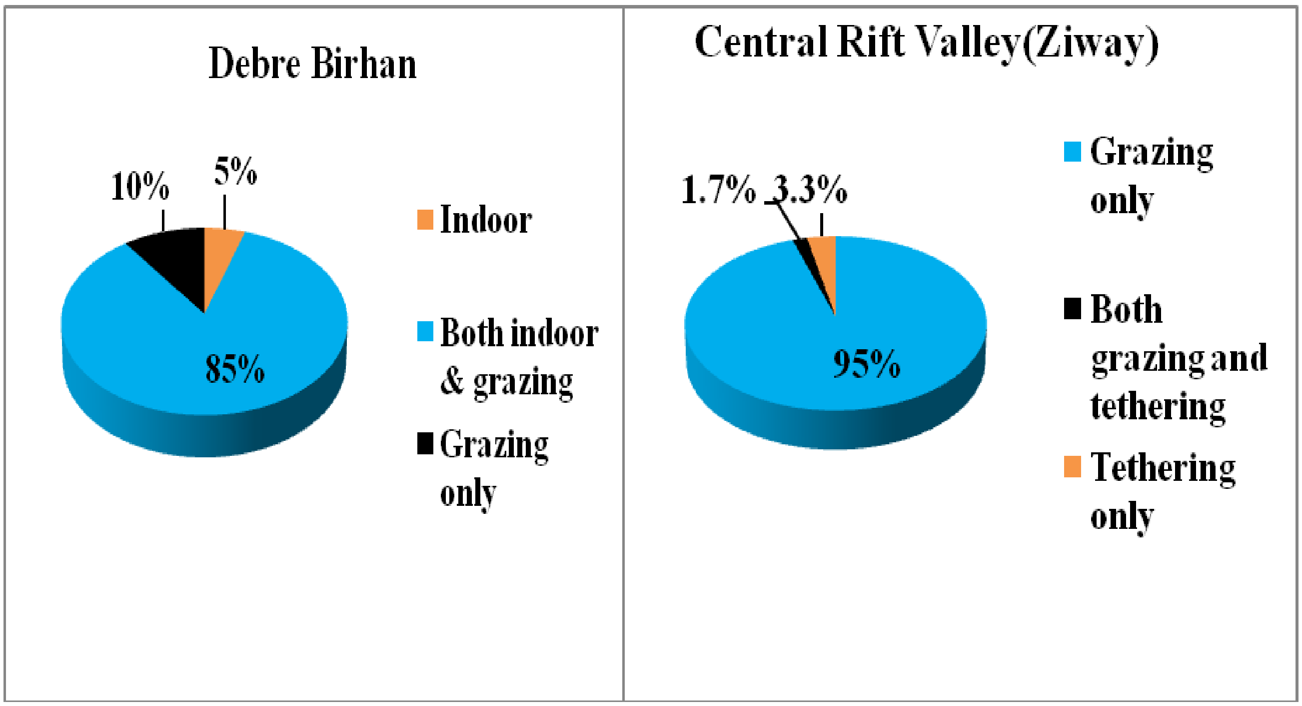
4.3.9. Feeding system

The Highland production system is dominated by intensive and specialized dairy farmers where most of the time depend on purchased feeds. In the Central Rift Valley production system, livestock production is extensive and largely depends on grazing lands and crop residues. In Jimma and Sebeta, there was no grazing land available and cattle do not have access to grazing. As a consequence cattle are kept indoor and fed individually or in a group. Feed types commonly used in these areas include grass hay, agro-industrial by products (noug seedcake and wheat bran), freshly cut green feeds, crop residues, brewery wet grains and local brewery by-products like *Atela*. The daily feed supply to animals was not measured by any of the dairy farmers rather feed was provided roughly based on the availability of feed and daily milk yield.

Around Ziway and Debre Birhan, cattle owners let their cattle to graze in own and rented pasturelands. Grazing on natural pastureland was predominant in both areas (Figure 6). In general animals graze between 8:00 AM and 6:00 PM when they go back home, but there were significant differences ($P<0.05$) between the length of grazing hours in both sites (Table 32). The estimated average grazing hours in Debre Birhan and around Ziway were 6.8±0.5 and 10.0±0.1 hours per day, respectively. The maximum grazing hour corresponds with the work of McDonald *et al*. (1995) who described that animals normally graze about eight hours per day, but some times as much as10 hours per day. In the peri-urban system of Debre Birhan herders brought their cattle back to home around lunchtime and would stay until 4:00 PM, which contributed to the shorter grazing period, compared to Ziway farmers. The purpose of bringing cattle back to home in the daytime was to provide additional feeds like hay and concentrates and protects their crossbred cattle from intense solar radiation because shade trees are not available in the area.

Table 32 Length of grazing hours (mean ±SE) in the Highland and Central Rift Valley

Production system	Grazing length (hour)
Highland	
Debre Birhan	6.8±0.5
CRV	
Ziway	10.0±0.1



The word tethering is used to indicate animals that are tethered at the plot border and around the home compound and also fed with cut and carry, crop residues etc.

Figure 6 Feeding systems employed by livestock owners at Debre Birhan and Ziway

4.3.10. Chemical composition and nutritive value of feeds

Chemical composition and nutritive value of the major feedstuffs in the study areas is shown in Table 33. The dry matter (DM) content of all crop residues was above 90%, which corresponds with Ahmed (2006), Sisay (2006) and Solomon *et al*. (2008b). The crude protein (CP) content of crop residues varied from 3.05% in oats straw to 6.74% in field pea straw. Lower CP value for oats reported in this study agrees with the report of Ahmed (2006). All crop residues evaluated had lower CP contents than the minimum level of 7% CP required for optimum rumen microbial function (Van Soest, 1982; Milford and Minson, 1966). The results of the current work agree with the report of Seyoum and Fekede (2008) that cereal crop residues are normally characterized by low digestibility and energy value, which are both inherent in their chemical composition. The mean *in vitro* digestible organic matter in the dry matter (IVDOMD) for cereal crop residues was about 47%, which is lower than the minimum level required for quality roughages (Daniel, 1988; Seyoum and Fekede, 2008). Stubbles of barley, wheat, *tef*, faba bean, field pea, haricot bean and oats had lower CP content than that of their corresponding straw. This could be associated with lower leaf to stem ratio of stubble crops (Ramazin *et al*., 1986; Ørskov, 1988; Solomon *et al*., 2008b). The lower content of CP for both crop residues and stubbles grazing may be compensated with strategic supplementation of proteinaceous feeds to improve livestock performance.

The energy content of crop residues ranged from 6.48 MJ/kg DM (wheat) to 7.89 MJ/kg DM (barley) straw. The energy contents for crop residues in this study were within the range reported by Seyoum and Fekede (2008), but higher than the value of 7.0 MJ/kg DM reported by Daniel (1988). Differences might be due to differences in management practices, soil fertility and/or crop variety used (McDowell, 1988).

The neutral detergent fiber(NDF) content of all crop residues was above 65%. Stubbles of major crops had slightly higher NDF contents than their straw. Sisay (2006) reported higher (> 70%) NDF contents for cereal crop residues and their stubbles. Roughage feeds with NDF content of less than 45% are categorized as high quality, 45-65% as medium quality and those with more than 65% as low quality roughages (Sigh and Oosting, 1992). All crop residues and stubbles in this study might be categorized as low quality roughages that may inflict limitations on animal performance.

Purchased hay and natural pasture had CP content of 6.13 and 7.20 % respectively. The current values are slightly closer to the minimum value reported by Van Soest (1982). Hay and native grass mixture had also high NDF content. NDF content of hay and native grass mixture reported in this study was closer to the values reported by Ahmed (2006) and Solomon (2004). The higher NDF content could be a limiting factor on feed intake, since voluntary feed intake and NDF content are negatively correlated (Ensminger *et al*., 1990). Similar to crop residues, both native grass and hay could be classified as low roughages, which could impose limitations on feed intake and animal production.

The ADF content of crop residues was varied from 48.2% in *tef* straw to 61.9% in haricot bean straw (Table 33). For crop stubbles, the range was from 58.7 to 71.5% ADF for field pea and oats, respectively. The ADF content for both crop residues and stubbles was within the range reported by Ahmed (2006) and Solomon *et al*. (2008b). However, Yitay (1999) reported a lower ADF values for barley and wheat straw, which could be attributed to differences in climate, crop management and soil fertility. Generally, Kellems and Church (1998) categorized roughages with less than 40% ADF as high quality and above 40% as low quality. All crop residues and stubbles could be categorized as low quality roughages. The ADF content for hay and native grass mixture was comparable to that of Zinash and Seyoum (1989), Yihalem (2004) and Ahmed (2006).

The lignin content was high for both crop residues and stubbles (Table 33), which limits DM intake. Lignin is completely indigestible and forms lignin-cellulose/hemicelluloses complexes (Kellems and Church, 1998) due to physical encrustation of the plant fiber and making it unavailable to microbial enzymes (McDonald *et al*., 1995). The lignin content for native grass mixtures and natural pasture hay was 8.3 and 10.6%, respectively. These values were higher than the maximum level of 7% that limits DM intake and livestock production (Reed *et al*., 1986).

Fodder trees had crud protein (CP) content ranging from 3.4 % in Papaya stem to 24.5% in *Rhus glutinosa* leaves (Table 33). Except papaya stem, the CP content for the other fodder trees leaves was in agreement with the report of Teferi (2006). The high CP content of browse species might allow chance to protein supplements for feeds of poor quality roughages and forages. The lowest NDF content was observed for *Clutia abyssinica* (19.6%) while the highest was for papaya stem (56.1%). Similarly, the ADF content was varied from 9.2% in *Clutia abyssinica* to 49.8% in papaya stem. High ADF content in fodder trees might be associated with lower digestibility since digestibility of feed and its ADF are negatively correlated (McDonald *et al*., 2002). Lignin content varied from 5.8% in B*alanites aegyptica* to 14.8% in papaya stem. The range of lignin contents for fodder tees in the present study is lower than those of Yitay (1999) which may be related to seasonal variation and its effect on cell wall lignifications (Larbi *et al*., 1998). Metabolizable energy content was high for *Clutia abyssinica* (10.2 MJ/kg DM) followed by *Balanites aegyptica* (9.9 MJ/kg DM)). The higher ME content could be associated with relatively lower proportion of fiber components.

Metabolizable energy (ME) of commonly used energy supplements such as wheat bran, molasses and *Atela* varied from 12.5 to 13.2 MJ/kg DM (Table 33). Molasses had the lowest CP content as compared with wheat bran and *Atela*. The cell wall contents of molasses was almost negligible whereas wheat bran had relatively higher fiber contents. The nutritional values for the current feeds are compatible with that of Seyoum and Fekede (2008). Seyoum *et al*. (2007) defined a standard for energy supplements as those feeds which contain high CP (13.9%), IVDOMD (82.2%) and ME (13.1 MJ/kg DM). With the exception of CP content of molasses, energy supplements (wheat bran, A*tela*) evaluated in the present work closely matched to this standard.

Among the protein supplements, brewery wet grains had slightly lower CP (26.8%) than cotton seed cake (42.0 %) and nouge seedcake (34.5%). This might be due to difference in the chemical composition and type of grains used as a raw material to produce these by-products (Yoseph *et al*., 2003c). The ME contents of protein supplements were not much different. The energy content, protein content and IVDOMD in protein supplements were high though slightly lower than the reported thresholds (Seyoum *et al*., 2007) for good quality protein supplements of (CP= 32.6%), (IVDOMD =65.5%) and (ME =10.2 MJ/kg DM).

Calcium (Ca) and Phosphorous (P) concentrations of the major feedstuffs in the study areas except for some fodder trees and barley straw were low as compared to the recommendations: <2.0 g/kg DM low, 2.0-3.5 g/kg DM normal and >4.0 g/kg DM high for both Ca and P (McDonald *et al*., 1995; Kellems and Church, 1998).

Table 33 Chemical composition and nutritive value of major feedstuffs in the study areas

Feedstuff	DM (%)	Chemical composition (% DM)						Nutritive values				
		Ash	OM	NDF	ADF	Lignin	CP	DCP (g/kg DM)	IVDOMD %	ME (MJ/kg DM)	Ca (g/kg)	P (g/kg)
Roughage												
Crop residue												
Wheat straw	93.41	9.47	90.53	80.31	56.30	13.10	3.14	25.69	43.18	6.48	0.2	0.9
Barley straw	91.62	8.53	91.47	76.77	52.84	12.14	3.55	29.5	52.59	7.89	3.3	0.8
Oats straw	92.36	7.07	92.93	75.25	54.53	15.04	3.05	24.85	48.81	7.32	0.4	1.0
Faba bean straw	92.59	6.56	93.44	73.41	50.96	9.97	6.13	53.47	47.11	7.07	1.5	0.8
Field pea straw	91.76	6.46	93.54	72.73	52.25	11.12	6.74	59.13	48.39	7.26	1.4	1.0
Haricot bean straw	92.38	7.06	92.94	75.09	61.86	16.81	6.73	59.04	46.64	7.00	1.4	0.6
Tef straw	93.07	9.08	90.92	79.90	48.17	10.92	4.22	35.72	48.15	7.22	0.2	1.3
Maize stover	93.33	10.38	89.62	83.06	52.19	10.62	3.52	29.22	44.11	6.62	0.3	0.9
Grass												
Purchased hay	92.43	13.73	86.27	76.04	49.24	10.61	6.13	53.47	48.68	7.30	0.4	1.3
Natural pasture	91.53	11.04	88.96	75.71	42.24	8.34	7.19	63.32	54.17	8.12	0.3	1.3
Non-conventional feeds												
Coffee pulp	90.33	9.04	90.96	55.45	48.58	6.65	11.13	99.92	49.04	7.36	0.5	1.1
Bean hull	90.87	3.06	96.94	72.71	61.42	8.19	6.54	57.28	55.96	8.39	0.6	3.0
Pea hull	91.02	3.62	96.38	58.57	40.82	7.45	16.38	148.69	63.66	9.55	0.4	2.0
Atela	21.83	5.80	94.20	60.21	22.53	11.02	21.00	167.27	87.8	13.20	0.2	0.6
Agro-industrial by-products												
Brewery wet grain	22.20	4.74	95.26	78.58	29.94	10.72	26.82	245.68	60.31	9.05	0.3	1.7
Wheat bran	86.53	4.42	95.58	52.84	8.13	-	16.87	153.24	83.00	12.45	0.16	0.8
Cotton seedcake	92.31	7.61	92.39	47.21	20.75	6.33	42.00	386.70	60.22	9.03	0.2	1.1
Noug seedcake	93.41	10.94	89.06	33.10	27.23	7.10	34.50	317.03	68.15	10.22	1.1	0.2
Molasses	72.35	18.50	81.50	-	-	-	3.99	29.04	99.69	14.95	0.81	0.15

Table 33 Continued

Feedstuff	DM (%)	Chemical composition (% DM)						Nutritive values				
		Ash	OM	NDF	ADF	Lignin	CP	DCP (g/kg DM)	IVDOMD %	ME (MJ/kg DM)	Ca (g/kg)	P (g/kg)
Browses												
Papaya stem	90.42	25.28	74.72	56.06	49.80	14.82	3.39	28.01	47.72	7.16	1.3	4.0
Clutia abyssinica	90.44	18.03	81.97	19.60	9.22	8.00	19.75	180.00	68.23	10.23	4.24	1.1
Rhus glutinosa	90.21	7.69	92.31	43.47	19.00	6.21	24.45	223.66	49.32	7.40	0.5	3.0
Balanites aegyptica	90.75	14.42	85.58	36.50	25.35	5.80	9.73	86.91	65.82	9.87	0.2	1.2
Acacia spp.	92.95	8.04	91.96	38.92	23.92	11.53	20.87	190.40	58.62	8.79	1.8	0.18
Crop stubbles												
Barley stubble	92.53	6.24	93.76	80.32	68.54	7.52	2.20	16.96	53.50	8.03	0.9	0.25
Wheat stubble	92.98	6.41	93.59	81.66	69.72	8.13	2.09	15.94	48.26	7.24	0.40	0.70
Tef stubble	93.30	9.87	90.13	76.94	65.36	6.85	1.79	13.15	49.84	7.48	0.62	0.12
Faba bean stubble	92.67	4.25	95.75	75.96	62.39	10.21	3.05	24.85	44.32	6.60	0.8	0.31
Field pea stubble	92.45	3.82	96.18	77.80	58.66	12.86	3.75	31.36	41.37	6.21	0.53	0.41
Haricot bean stubble	91.56	6.23	93.77	78.91	65.45	9.61	2.72	21.79	42.15	6.30	0.42	0.33
Oats stubble	93.15	7.32	92.68	79.82	71.53	7.68	1.95	14.64	50.20	7.53	0.31	0.21

Atela = a by-product of local beverages called '*Tela'*

4.3.11. Estimated annual feed availability

The total estimated feed dry matter (DM), digestible crude protein (DCP) and metabolisable energy (ME) production per farm in the Highland and Central Rift Valley (CRV) production system is shown in Table 34. The major feed resources in the Highland production system include hay, agro-industrial by-products while natural pasture, crop residue and crop stubbles in the CRV (Ziway). However from Highland production system farmers at Debre Birhan heavily relay on crop residues compared to Jimma and Sebeta. The largest portion of dry matter yield was obtained from crop residues in both Debre Birhan and Ziway areas. Among crop residues, maize stover represented the largest share of dry matter production in Ziway and barley straw in Debre Birhan. Most of the indigenous browse trees in Central Rift Valley (Ziway) are longer in height and inaccessible to animals, as a result dry matter yield obtained from them was not considered in the estimation. Total dry matter produced in Jimma and Sebeta was the sum of grass hay, concentrate feeds and crop residues. Use of improved fodder trees as animal feed in the peri-urban Highland study sites was rare and the dry matter calculation did not account these feed resources. In the Highland system, the total amount of feed dry matter estimated per annum per farm was 26.3, 27.6 and 25.2 t at Debre Birhan, Jimma and Sebeta , respectively. In the same system the total estimated DCP was 1711, 2620 and 2799 kg while the total ME was 218162, 258524 and 214427 MJ per farm per annum in Debre Birhan, Jimma and Sebeta, respectively. In the Central Rift Valley (Ziway) the total DM, DCP and ME estimated per annum per farm were 21.3 t, 725 kg and 146393 MJ, respectively.

The total estimated dry matter, DCP and DM supply for farms with small herd size were 57.5 t, 4700 kg, and 478726 MJ per year per farm, respectively (Table 35). Similarly, a total of 101 t DM, 9493 kg DCP and 885546 MJ ME per annum per farm were estimated for farms with medium herd size. Medium herd size holders had higher estimated DM, CP and ME production per annum than the corresponding small herd size holders with the exception of medium herd size holders at Debre Birhan. The relatively low DM, CP and ME for medium herd size holders at Debre Birhan might be related to small size of land for crop production and grazing compared with the small herd size holders in the same area.

Table 34 Estimated available dry matter productions, DCP and ME supply per annum per farm in the Highland and Central Rift Valley

Feedstuffs	Highland									CRV		
	Debre Birhan			Jimma			Sebeta			Ziway		
	DM (t)	DCP (kg)	ME (MJ)	DM (t)	DCP (kg)	ME (MJ)	DM (t)	DCP (kg)	ME (MJ)	DM (t)	DCP (kg)	ME (MJ)
Crop residue												
Wheat straw	0.8	20.8	5237.9	-	-	-	4.6	119.1	30047.8	2.6	66.4	16750.6
Barley straw	7.3	215	57504.8	-	-	-	-	-	-	0.6	17.7	4744.4
Tef straw	-	-	-	-	-	-	-		-	0.7	23.4	4719.2
Haricot bean straw	-	-	-	-	-	-	-	-	-	1.0	57.4	6804.0
Field pea straw	0.3	18.7	2293.4	-	-	-	-	-	-	-	-	-
Faba bean straw	0.5	28.2	3722.4	-	-	-	-	-	-	-	-	-
Oats straw	0.7	18.4	5422.8	-	-	-	-	-	-	-	-	-
Maize stover	-	-	-	-	-	-	-	-	-	12.2	355.8	80601.8
Crop stubbles	1.6	29.0	11960.0	-	-	-	-	-	-	1.3	22.3	9387.8
Grass												
Natural pasture	2.7	172.6	22127.0	-	-	-	-	-	-	2.9	182.4	23385.6
Hay	8.2	435.5	59451.2	14.4	770.4	105178.4	10.2	542.4	74054.9	-	-	-
Agro industrial by-products												
Wheat bran	3.2	490.4	39840.0	8.7	1337.8	108688.5	4.2	643.6	52290.0	-	-	-
Noug seedcake	0.9	279.0	8993.6	-	-	-	1.0	317.7	10240.4	-	-	-
Cotton seedcake	-	-	-	-		-	0.01	4.6	108.4	-	-	-
Molasses	0.1	3.7	1609.1	0.1	3.5	1520.4	0.3	9.1	3978.4	-	-	-
Brewery wet grain	-	-	-	-	-	-	4.7	1143.2	42109.7	-	-	-
Non-conventional feeds												
Atela	-	-	-	0.8	134.3	10575.5	0.1	6.6	521.3	-	-	-
Pulse hulls	-	-	-	3.6	373.9	32561.1	0.1	12.4	1076.4	-	-	-
Total	**26.3**	**1711.3**	**218162**	**27.6**	**2620.0**	**258524.0**	**25.2**	**2798.7**	**214427**	**21.3**	**725.4**	**146393.4**

Atela = a by-product of local beverages called '*Tela*'

Table 35 Estimated annual DM (t) production, DCP (kg) and ME (MJ) supply in the Highland production system by herd size

Feedstuffs	Small herd size									Medium herd size								
	Debre Birhan			Jimma			Sebeta			Debre Birhan			Jimma			Sebeta		
	DM	DCP	ME	DM	DCP	ME	DM	DCP	ME	DM	DCP	ME	DM	DCP	ME	DM	DCP	ME
Crop residues																		
Wheat straw	1.6	41	10368							0.7	18	4536				8.6	220	55728
Barley straw	7.7	191	51048							6.9	172	45999						
Field pea straw	0.6	35	4356							0.03	2	218						
Faba bean straw	0.9	48	6363							0.15	8	1061						
Oats straw	0.5	11	3360							0.1	25	74865						
Crop stubble	1.5	29	11360							1.6	29	12459						
Natural pasture	2.2	142	18189							3.2	204	26146						
Hay	9.1	485	66269	9.3	498	68007	6.3	337	46027	7.2	386	52633	19.5	1043	142350	14	748	102083
Non-conventional feeds																		
Atela	-	-	-	0.6	105	8287	-	-	-	-	-	-	1.0	163	12865	0.08	13	1043
Field peas and faba beans hull	-	-	-	2.2	229	19913	0.24	25	2153	-	-	-	5.0	519	45209	-	-	-
Agro-industrial by-products																		
Wheat bran	2.8	429	34860	4.3	664	45465	2.6	405	32868	3.6	552	44820	13.1	2012	163469	5.8	883	71712
Noug seedcake	0.6	203	6541	-	-	-	0.02	8	245	1.1	355	11446	-	-	-	2	628	20236
Cotton seedcake	-	-	-	-	-	-	0.02	9	217	-			-	-	-	-	-	-
Molasses	0.04	1	558	0.1	4	1520	0.24	7	3041	0.2	6	2661	0.1	4	1520	0.4	11	4916
Total	**27.5**	**1616**	**213272**	**17**	**1499**	**151636**	**13**	**1585**	**113818**	**26**	**1758**	**209464**	**38**	**3741**	**365412**	**37**	**3994**	**310670**

4.3.12. Estimated annual feed balance

The total annual nutrient intake, nutrient requirement and feed balances in the study areas are shown in Table 36. In the Highland production system, the estimated available feed supply met about 83% of the maintenance DM requirement of livestock per farm per year while the total estimated DCP and ME were 40 and 10% surplus per year per farm. Among the Highland production system, in Debre Birhan the existing feed supply on a year round basis satisfies only 64% of the maintenance DM requirement of the animals per farm. Similarly, the total available DCP and ME in the same area satisfy only 66% and 81% of the total livestock requirement per farm on a yearly basis. In Jimma, total annual DM requirement was 11.5% less than the annual DM requirement for maintenance. On the other hand, the total DM, DCP and ME were 51% and 25% per farm, respectively, above the total annual requirement. In Sebeta, the total annual DM requirement was 3% less than the requirement for maintenance while total DCP and ME were 102% and 26% above the total annual requirement per farm. Surplus DCP and ME above the maintenance requirement in Jimma and Sebeta could probably be attributed to the use of better energy and protein supplements. In the CRV (around Ziway), the total annual DM meets only 66% of the total livestock requirement per annum per farm. In the same way, the total yearly available DCP and ME cover only 37% and 67% of the total livestock requirement per farm, respectively. The larger deficit observed under this area may be associated with poor quality of roughages and absence of supplements. Negative balance of DM requirement observed in the current study agrees with other works reported indifferent areas (Adugna and Said, 1994; Tessema *et al*., 2003). However, Sisay (2006) reported surplus DM supply than the total annual livestock requirement at North Gondar.

The total nutrient supply and nutrient requirement by herd size is presented in Table 37. The total Dry matter met only 85% and 79% of the total DM requirement per farm per annum for farms with small and medium herd sizes, respectively. Regardless of study sites in the Highland system, the total available DCP and ME per annum were according to the livestock requirement for both small and medium herd sizes. In the urban and peri-urban system of the Addis Ababa milk shed, Yoseph *et al*. (2003a) reported negative energy intake and a positive balance for DCP intake. The annual feed supply on a year round base meets only 83, 76, and

97 % of the DM, DCP and ME total requirements per farm, respectively for small herd size holders in Debre Birhan. For medium herd size holders in Debre Birhan the existing feed supply only covers 53% of the DM, 59% of the DCP and 65 % of the ME total annual requirements per farm. High nutrient deficit observed at Debre Birhan might be attributed to the lack of land to produce feed and poor nutritive value of the major feeds (crop residues) in relation with the greater number of livestock population in the area. For small herd sizes holders in Jimma the feed supply covered 92% DM requirements of animals for maintenance whereas DCP and ME was 49% and 28% respectively, higher than the total annual requirements per farm. For medium herd sizes, there was a shortage of 13% in the DM requirements, and DCP and ME were 52% and 24% in over supply per annum per farm. In Sebeta, except for DM requirements, total energy and protein supply were above the annual requirements both at small and medium herd sizes.

Table 36 Estimated annual feed dry matter and nutrient balance of livestock per farm per annum in the Highlands and Central Rift Valley production system

Production system	Annual nutrient supply			Estimated annual nutrient requirement			Balance of supply and requirements		
	TDM (t)	TDCP (kg)	TME (MJ)	TDM (t)	TDCP (kg)	TME (MJ)	TDM	TDCP	TME
Highland									
Debre Birhan TLU=20.1	26.4	1711.1	218162	41.4	2602	270912	-15(64.0%)	-891(65.8%)	-52750(80.5%)
Jimma TLU=14.3	27.6	2620.0	258524	31.2	1733	206889	-3.6(88.5%)	+887(151.2%)	+51635(125.0%)
Sebeta TLU=12.5	25.2	2798.7	219427	26.0	1387	174106	-0.8(96.9%)	+1412(201.8%)	+45321(126.0%)
Average	**26.4**	**2376.6**	**232038**	**32.9**	**1907.3**	**217302**	**-6.5(83.1%)**	**+469(139.6%)**	**+14736(110.5%)**
CRV									
Ziway TLU=15.6	21.3	725.4	146393	32.1	1987	217868	-10.8(66.4%)	-1262(36.5%)	-71475(67.2%)

TDM=Total Dry Matter, TDCP=Total Digestible Crude Protein, TME=Total Metabolizable Energy, CRV= Central Rift Valley

Table 37 Estimated annual feed dry matter and nutrient balance of livestock per farm in the Highland production system by herd size

Herd size category	Study sites	Annual nutrient supply			Estimated annual nutrient requirement			Balance of supply and requirements		
		TDM (t)	TDCP (kg)	TME (MJ)	TDM (t)	TDCP (kg)	TME (MJ)	TDM	TDCP	TME
Small	DB (TLU= 16.3)	27.6	1616	213272	33.4	2114	219442	-5.8(82.6%)	-498(76.4%)	-6170(97.2%)
	Jimma (TLU=8.0)	16.5	1499	151636	17.9	1009	118706	-1.4(92.2%)	+490(148.6%)	+32930(127.7%)
	Sebeta (TLU=7.5)	12.8	1585	113818	15.9	857	106012	-3.1(80.5%)	+728(185.0%)	+7806(107.4%)
Subtotal	**TLU=31.8**	**56.9**	**4700**	**478726**	**67.2**	**3980**	**444160**	**-10.3(84.7%)**	**+720(118.1%)**	**+34566(107.8%)**
Medium	DB (TLU=23.8)	25.7	1758	209464	49	3004	322381	-23.3(52.5%)	-1246(58.5%)	-112917(65.0%)
	Jimma (TLU=20.5)	38.5	3741	365412	44	2457	295072	-5.5(87.5%)	+1248(152.3%)	+70340(123.8%)
	Sebeta (TLU=17.4)	37	3994	310670	36	1917	242200	+1.0(102.8%)	+2077(208.4%)	+68470(128.3%)
Subtotal	**TLU=61.7**	**101.2**	**9493**	**885546**	**129**	**7378**	**859653**	**-27.8(78.5%)**	**+2115(128.7%)**	**+25893(103.0%)**
Grand total	**TLU=93.5**	**158.1**	**14193**	**1364272**	**196.2**	**11358**	**1303813**	**-38.1(80.7%)**	**+2835(125.0%)**	**+60459(104.6%)**

DB= Debre Birhan, TDM=Total Dry Matter, TDCP=Total Digestible Crude Protein, TME=Total Metabolizable Energy

4.4. Marketing of Feed, Cattle and Dairy Products in Highlands and Central Rift Valley Production System

4.4.1. Feed marketing

It was observed that feed resources under highland system are relatively expensive compared to Central Rift Valley (Table 38). Among Highland system, in Sebeta area the price of brewery wet grain was lowest (ETB 0.18 per kg) and noug seedcake was the highest (ETB 2.23 per kg) followed by wheat bran (ETB 2.13). In both Debre Birhan and Jimma area, nouge seedcake had the highest price (ETB 2.25 and 2.41 per kg, respectively). The price of *Atela* and field pea and faba beans hull was the lowest in Debre Birhan and Jimma area, respectively. In Jimma, agro-industrial by-products were not readily available, despite the high prices. The problem might be partly associated with the fact that there are no agro-processing industries in the area and that there are limited suppliers from other areas. The average prices for most of the feeds in this study are within the range of prices reported by Berhanu *et al*. (2009) in different parts of Ethiopia. There was not much price variation among major crop residues except for green maize stover in Ziway area. Green feed and crop residues were the major feeds supplied at Ziway market. Green maize stover that was produced under irrigation in the dry period was commonly available at the market in Ziway area. In the same area crop residues were available at the market from the period of crop harvest (October) to one or two months later after crop collection (January). At Ziway market, soon after the cessation of the main rain period, green grass comprised the largest feed market volume. However, the total amount supplied to the market was not quantified. Most feeds were sold to smallholder dairy farmers, fatteners and cart-horse/donkey owners in the town.

Regardless of the study sites, price per unit of digestible crude protein (DCP) feeds varied from ETB 0.003 for Atela to 0.03 for molasses. Brewery wet grain had the lowest price per unit of metabolizable energy (ME) while noug seedcake had the highest (Table 38). The lower price per unit ME for brewery wet grains implies that dairy farms located close to brewery factories probably do have better economic benefits.

Table 38 Mean (±SE) price (ETB) per kg of available feed resources on as fed and per nutrient basis in the study sites.

Feed type	Highland			CRV	Price per nutritive value	
	Debre Birhan market	Jimma market	Sebeta market	Ziway market	Price per unit (g) of DCP	Price per unit ME
Natural pasture hay	-	0.75±0.05	1.23±0.03	-	0.019	0.14
Native green grass	-	-	-	0.48±0.03	0.008	0.06
Barley straw	0.70±0.20	-	-	0.62±0.03	0.021	0.08
Wheat straw	-	-	0.73±0.03	0.64±0.08	0.026	0.13
Tef straw	-	-	-	0.77±0.07	0.022	0.11
Haricot bean straw	2.00±0.03	-	-	0.60±0.05	0.010	0.08
Maize stover	-	-	-	0.32±0.03	0.011	0.05
Field peas and faba beans hull	-	0.60±0.08	-	-	0.006	0.07
Atela	0.50±0.05	0.61±0.12	-	-	0.003	0.04
Wheat bran		2.13±0.10	2.00±0.05	-	0.014	0.17
Noug seedcake	2.25±0.05	2.41±0.08	2.23±0.03	-	0.007	0.23
Brewery wet grain	-	-	0.18±0.00	-	0.006	0.02
Molasses	0.73±0.30	1.05±0.03	0.70±0.05		0.030	0.06

During the study period the average exchange rate was 12.42 ETB = 1 USD

4.4.2. Marketing of cattle

Most often, brokers are involved in the market to negotiate the price difference between sellers and purchasers. Local market prices of both crossbreds and local breed cattle in the study areas are shown in Figure 7. Selling/purchasing price of adult crossbred cows ranged from Ethiopian Birr (ETB) 5,000.00 to 12,000.00 with an average of 8,838.00. Minimum and maximum selling/purchasing prices for heifers were ETB 3,000.00 to 11,000.00, respectively. Crossbred male calves were sold at low prices at an early age in peri-urban areas of Jimma and Sebeta but in peri-urban areas of Debre Birhan, they remained in the herd for traction purposes. When these oxen are too old, they will be fattened and sold with a price closer to the price of crossbred heifers.

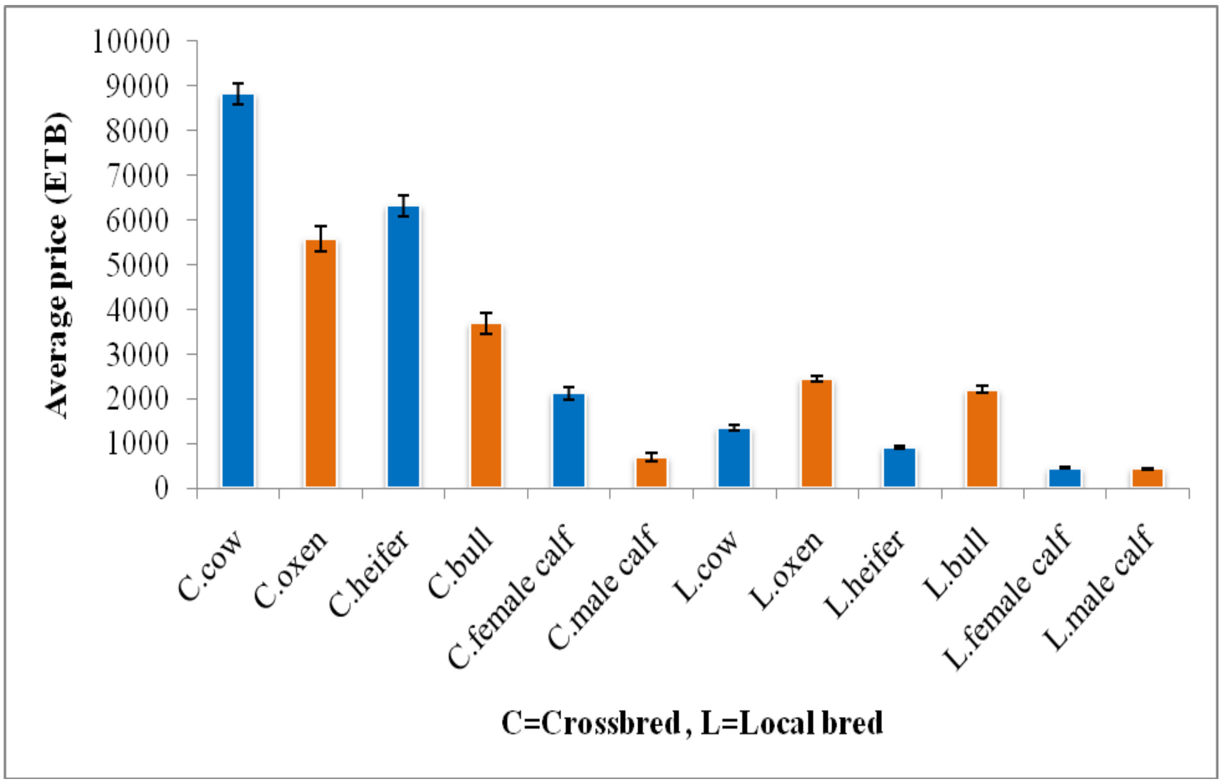


Figure 7 Market prices of crossbred and local cattle across the study sites.

During the study period the average exchange rate was 12.42 ETB = 1 USD

Among the local cattle herd, the selling price was higher for local bred oxen and bull compared to others and varied from ETB 2000.00 to 6000.00. A slight rise in price for local oxen and bull could be due to the relative importance for traction as well as source of income in the former and preferred meat quality in the later as traditionally perceived by the local community.

4.4.3. Milk and milk products marketing

Commonly sold type of dairy products and market types in the Highland peri-urban production and Central Rift Valley are indicated in Table 39. Except livestock owners in and around Ziway town, selling of whole milk was occasionally observed in the rural areas of Central Rift Valley system. Cattle breeds maintained in this area are indigenous zebu which produce little amount of milk per day. Instead of selling of whole milk, farmers in these areas prefer to collect some days' milk together and process it into butter and traditional *Ayib* for sale or home consumption. Marketing of whole milk somehow also influenced by cultural taboos. In the Central Rift Valley, butter was the main product sold (56% of respondents) followed by both butter and *Ayib* (42.4%).

In contrast to Central Rift Valley system, marketing of whole milk is common in Highland system. In Debre Birhan, Jimma and Sebeta, 40, 95 and 90% of the dairy farmers respectively, were involved in selling whole milk to the market. In Debre Birhan and Sebeta, 45 and 90% of the dairy farmers sold whole milk to milk collection centers while in Jimma, it was sold to local markets such as cafeterias, hotels and hospitals. As a result the amount of milk processed at home was quite little. In Debre Birhan, 55% the dairy farmers sold milk either to local market or to milk collection centers. During the Orthodox fasting periods more milk was not sold in Debre Birhan area. Around Ziway almost all of the respondents sold milk products to local markets.

The average price of milk and milk products in wet and dry seasons in the study areas is indicated in Figure 8. The price for locally processed products such as butter and *ayib* was highest in the dry season in all study areas. In Debre Birhan, during the main Orthodox fasting period (in dry season), the price of whole milk was lower than any other periods. It has been reported that during rainy season and fasting periods, demand decreases and results in curtailment of the incoming raw milk volume from the producers to match the supply with sales (Zegeye, 2003).

In both dry and wet seasons, price for butter was highest at Sebeta while it was slightly lower in Jimma (Figure7). Price variations for butter between sites might be attributed to proximity of the sites to big towns/cities such as Addis Ababa. The average price of whole milk was higher at Jimma than Debre Birhan and Sebeta. Better price of whole milk in Jimma is related to the existence of range of customers (cafeterias, hotels, hospitals and individuals) and insignificant effect of fasting.

Table 39 Dairy products marketing and market types in the Highlands and Central Rift Valley production system

Production system	Dairy products					Market types		
	Whole milk	Butter	Whole milk and butter	Butter and *Ayib*	Whole milk, butter and *Ayib*	LM	MCC	Both LM and MCC
Highland								
DB (n=20)	40%	-	60%	-	-	-	45%	55%
Jimma (n=20)	95%	-	5%	-	-	100%	-	-
Sebeta (n=20)	90%	-	-	-	10%	5%	90%	5%
Subtotal	**75%**	**-**	**22%**	**-**	**3%**	**35%**	**45%**	**20%**
CRV								
Ziway (n=60)	-	56%	-	42%	2%	98%	-	2%

n= number of respondents, LM= local market, DB= Debre Birhan, MCC=milk collection centers, *Ayib* 'a traditional fermented Ethiopian dairy product made commonly by heating sour milk after the butter is removed through churning.'

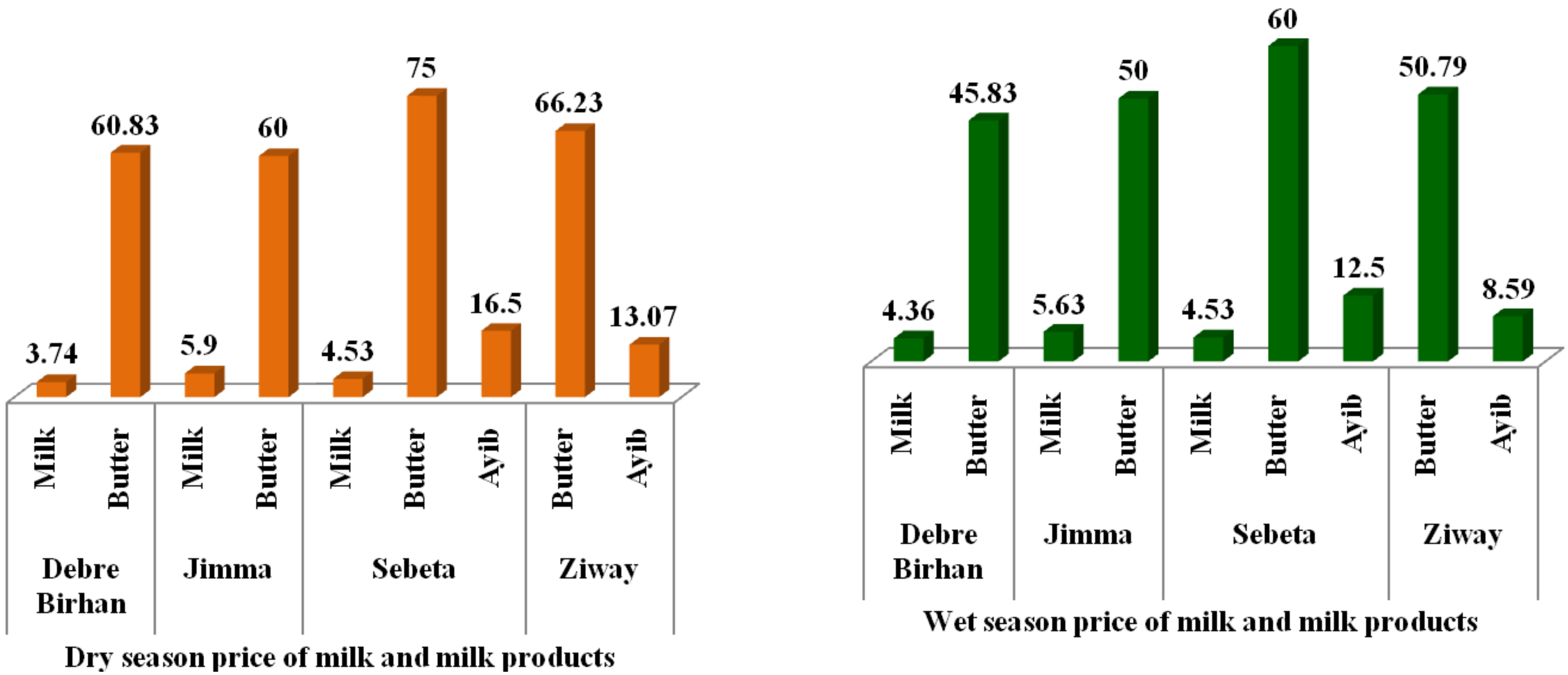


Figure 8 Average price of milk and milk products (ETB per kg) in dry and wet seasons in the study areas

During the study period the average exchange rate was 12.42 ETB = 1 USD

5. SUMMARY AND CONCLUSIONS

In this study, assessment of available feed resources was conducted in two livestock production systems viz. peri-urban dairy system of the highlands and mixed-crop livestock system of the Central Rift Valley (CRV). Debre Birhan, Sebeta and Jimma were considered to represent the Highland peri-urban dairy system while Ziway was a representation of CRV livestock production system. Among the Highland peri-urban study sites only farmers at Debre Birhan had farmlands while those at Jimma and Sebeta did not have any farm land. In the Central Rift Valle crop-livestock mixed farming system is dominant. The peri-urban dairy system of the Highland is focused on crossbred dairy cows of any exotic blood level inheritance while in the Central Rift Valley system animals were of indigenous breed types. A survey was undertaken in both Highland and Central Rift Valley production systems and data were collected on family structure, farm size, land use pattern, herd size, herd composition, purpose of livestock raising, daily milk yield, crop grain yield, major crops grown, livestock feed types, feed markets, milk price, milk market place, age at first parturition, calving interval, lactation length, days open, mating systems, dry matter (DM) production, quantity of total feed and types of houses to keep livestock. Laboratory analysis was carried out to evaluate chemical composition and nutritive value of major feed resources collected from each study site.

The survey results indicated that the mean herd size per household in both Highland and Central Rift Valley was 15.6 TLU. The average number of sheep per household was significantly ($P<0.05$) higher in the highland production system whereas the average number of goats was the higher in the Central Rift Valley. The average number of horses per household was much larger ($P<0.05$) at Debre Birhan than the rest of the study sites.

Assessment of feed resources indicated that Highland production system is dominated by intensive and specialized dairy farmers where most of the time depend on purchased feeds. In the Central Rift Valley, livestock production system is extensive and largely depends on grazing lands and crop residues. In Jimma and Sebeta, there was no grazing land available and cattle do not have access to grazing. Feed types commonly used in these areas include grass hay, agro-industrial by products (noug cake and wheat bran), freshly cut green feeds, crop residues, brewery wet grains and local brewery by-products like *Atela*. The major feed resources in the Central Rift Valley (Ziway) were natural grazing pasture and crop residues. Feed shortage was commonly observed in the dry season of the year in all study sites. Accordingly, 90% of the participants in the Central Rift Valley described feed shortage followed by water scarcity (70%) in the dry period as the major constraints to livestock production. In the Highland peri-urban production system, about 58% of the respondents face feed shortage during dry season. About 65% of the respondents in Debre Birhan area encountered feed shortage in wet season and 80% of the respondents in Jimma during dry season. Among the small herd size dairy farms, 90% in Debre Birhan and 40% in Sebeta did not have enough feed in wet seasons. All medium herd size dairy farms in Jimma while 60% of them in both Debre Birhan and Sebeta encountered feed shortage in the dry season. In the Highland peri-urban production system, about 63% of the dairy farmers reported feed shortage associated with the escalating price of feed in the market. In the same area, about 52% of the farmers did not have land to grow forages. In addition, 45% of the farmers reported that commercial supplement feeds are not sufficiently available in the market.

Survey of the productive and reproductive performance of dairy cows indicated that the overall estimated mean daily milk yield in the Highland peri-urban production system was 7.6±0.3 kg. The estimated daily milk yield was higher (9.7±0.5 kg) at Sebeta while it was lower (6.1±0.4 kg) at Debre Birhan. In the Central Rift Valley (Ziway), the dominant breed of cattle is indigenous Arsi zebu and the overall estimated mean milk yield from this breed was about 1.5±0.3 kg/day. Over all mean lactation length for cows in the peri-urban study sites was 296.5±8.7 days. In the Central Rift Valley, the estimated mean lactation length was 320.5±32.3 days. The overall estimated mean ages of heifers at first service and mating were 27.5±1.0 and 36.8±1.0 months for Highland peri-urban study sites, respectively. Heifers at Sebeta area had the shortest age at fist service (24.3±1.7 months) and age at first calving (33.6±1.7 months). The overall estimated mean ages at first service and calving for heifers in the Central Rift Valley (Ziway) were longer (51.1±5.0 and 60.4±5.0 months, respectively).

The overall estimated mean calving interval and days open in the Highland study areas were about 471.5±20.1 and 191.5±20.1 days, respectively. On the other hand, in the Central Rift Valley (Ziway), the overall estimated calving interval and days open for local cattle breeds were 662±83 and 382±83 days, respectively. About 52 and 97% of the respondents in the Highland and Central Rift Valley production systems, respectively, used only natural service. Artificial Insemination (AI) service was almost absent in the CRV while 23% of the farmers get access of it in the Highland production system. About 25% of the farmers in the Highland peri-urban production system use a combination of AI and natural mating. More than half of the respondents at Sebeta had access to AI service while 75% of the respondents at Debre Birhan and Jimma use natural mating. Al service has not yet been introduced at a large scale in areas, which are located further away from Addis Ababa.

Assessment of biomass production in the Central Rift Valley shown that biomass yield of grasses, forage legumes and forbs was 3597 kg ha^{-1}, 67.4 kg ha^{-1} and 298.5 kg ha^{-1}, respectively. Dry matter yield obtained from legumes was lowest (12.7 kg ha^{-1}) while it was higher for grasses (1172.5 kg ha^{-1}).

Laboratory evaluation of major feeds collected from all study areas showed that the crude protein (CP) content of crop residues varied from 3.05% in oats straw to 6.74% in field pea straw. All crop residues in the current study had lower CP contents than the minimum level of 7% CP required for optimum rumen microbial function. Similarly, crop stubbles had lower CP content. The mean *in vitro* digestible organic matter in the dry matter (IVDOMD) for cereal crop residues was about 47%, which might be lower than the minimum level required for quality roughages. The energy content of crop residues ranged from 6.48 MJ/kg DM (wheat) to 7.89 MJ/kg DM (barley) straw. Acid detergent fiber, neutral detergent fiber and lignin contents evaluated were high for both crop residues and stubbles. The lower content of CP for both crop residues and crop stubbles may be compensated with strategic supplementation of proteinaceous feeds to improve livestock performance.

Metabolizable energy (ME) of commonly used energy supplements such as wheat bran, molasses and *Atela* varied from 12.5 to 13.2 MJ/kg DM. Molasses had the lowest CP content.

With the exception of CP content of molasses, energy supplements (wheat bran, A*tela*) evaluated in the present work closely matched with the standard recommended for Ethiopian feeds. Among the protein supplements, brewery wet grains had slightly lower CP (26.8%) than cotton seed cake (42.0 %) and nouge cake (34.5%). The energy content, protein content and IVDOMD in protein supplements were sufficient to improve livestock performance. Calcium (Ca) and Phosphorous (P) concentrations of the major feedstuffs were low. This indicates that supplementary mineral diets are required particularly for high yielding animals.

Estimation on annual feed availability indicated that the total amount of feed dry matter, DCP and ME per farm per annum in the Highland production system was 79.1 t, 7130 kg and 691113 MJ, respectively. Similarly in the Central Rift Valley (Ziway) the total DM, DCP and ME estimated were 21.3 t, 725 kg and 146393 MJ, respectively. In the Highland production system, the estimated available feed supply met about 83% of the maintenance DM requirement of livestock per farm per year while the total estimated DCP and ME were 40 and 10% surplus per year per farm. In Debre Birhan, the existing feed supply on a year round basis satisfies only 64% of the maintenance DM requirement, 66% of DCP and 81% of ME requirements. In Jimma, total annual DM requirement was 11.5% less than the annual DM requirement for maintenance. Similarly, the total DCP and ME were 51% and 25% per farm, respectively, above the total annual requirement. In Sebeta, the total annual DM requirement was 3% less than the requirement for maintenance while total DCP and ME were 102% and 26% above the total annual requirement per farm. In the CRV (around Ziway), the total annual DM meets only 66% of the total livestock requirement per annum per farm while the total yearly available DCP and ME cover only 37% and 67% of the total livestock requirement per farm, respectively. It can be deduced from current available feed requirement estimation that the total feed dry matter was deficit in both Highland and Central Rift Valley production systems.

Assessment of market price of feeds and milk showed that in the Highland study sites noug seedcake had the highest price and varied from ETB 2.13 to 2.41 per kg feed. In Sebeta area the price of brewery wet grain was lowest (ETB 0.18 per kg feed). Regardless of the study sites, price per unit of digestible crude protein (DCP) of feeds varied from ETB 0.003 for

Atela to 0.03 for molasses. Brewery wet grain had the lowest price (ETB 0.02) per unit of metabolizable energy (ME) while noug seedcake had the highest (ETB 0.23). The lower price per unit ME for brewery wet grains implies that dairy farms located close to brewery factories probably do have better economic benefits.

Farmers in Ziway area prefer to collect some days' milk together and process it into butter and traditional *Ayib* for sale or home consumption. In the Central Rift Valley, butter was the main product sold (56% of respondents). In Debre Birhan and Sebeta, 45 and 90% of the dairy farmers sold whole milk to milk collection centers while in Jimma, it was sold to local markets such as cafeterias, hotels and hospitals. The price for locally processed products such as butter and A*yib* was highest in the dry season in all study areas. In Debre Birhan, during the main Orthodox fasting period (in dry season), the price of whole milk was lower than any other periods. In general, price of butter increased for sites located closer to big towns/cities such as such as Addis Ababa.

Therefore, from the current study it was concluded that the quality of available basal roughage feeds is generally low and strategic supplementation of protein and energy rich feeds should be required. Alternative means of dry season feed production and supply should be in place with the involvement of all stakeholders and development actors. In relation with the rising market price of concentrate feeds, other optional feeds like brewery wet grains and non-conventional feed resources should be further considered.

6. RECOMMENDATIONS AND SCOPE FOR FUTURE RESEARCH

- Lack of land in the peri-urban areas for livestock farming particularly for dairy needs attention to formulate clear and workable policy by assessing the real situation at the grass root level.

- Further research and development work to alleviate dry season feed shortage through different options such as utilization of non-conventional feeds, development of improved forages with the use of irrigation and alternative means of crop residue utilization.

- Feed is the major bottleneck for the current peri-urban dairy production. Encouraging private investors to be involved in commercial animal feed production (forage production and agro-industrial feed processing).

- It was noted that farmers lack awareness on the use of improved forages and hence consolidated extension service required.

- In this study, it was found difficult to determine exotic blood level of crossbred cows. As a result estimation of the performance of cattle was also done based on survey data as there was no record at farm level. Thus, further work on record keeping need to be addressed.

- Detailed monitoring research is imperative to further investigate on productive and reproductive performance of cattle.

- Detailed monitoring research on the existing practice of ration formulation by the farmer.

- Better milk yield observed at Sebeta area could be a point of interest to further study on the biological and economic efficiency of feeding agro-industrial by-products such as brewery wet grain for dairy cattle kept close to brewery factories.

7. REFERENCES

Ababu, D., 2002. Evaluation of performance of Borana cows in the production of crossbred dairy heifers at Abernosa ranch Ethiopia. An MSc. Thesis, Alemaya University. Dire Dawa, Ethiopia. 38p.

Abate, T. and Abiye, A., 1993. Some Methods of Introducing forage Legumes into the smallholder Mixed Farms in the Ethiopian Highlands. PP.11. In: Proceedings of Symposium on environmental degradation. Mekele, Ethiopia, 15-20, April 1992, Mekele University, Mekele, Ethiopia.

Abdinasir, I., 2000. Smallholder Dairy Production and Dairy Technology Adoption in the Mixed Farming System in Arsi highland, Ethiopia. PhD. Dissertation, Humboldt University, Berlin, Germany. 146p.

Adugna, T. and Aster, A. 2007. Livestock production in pastoral and agro-pastoral production systems of southern Ethiopia. *Livestock Research for Rural Development*. http://www.cipav.org.co/lrrd/lrrd 19/12/cont1912.htm, (Accessed on January 5, 2009).

Adugna, T. and Said, A.N., 1994. Assessment of feed resources in Welayta Sodo. *Ethiopian Journal of Agricultural Science.* 14(1/2): 69-87.

Agajie, T., Ebrahim, J., Sitotaw, F. and David, G. Smith, 2005. Technology Transfer Pathways and Livelihood Impact Indicators in Central Ethiopia. *Journal of Tropical Animal Health and Production.* 37 (1): 101-122.

Ahmed, H., 2006. Assessment and Utilization Practice of Feed Resources in Basona Worana Wereda of North Shoa, An MSc. Thesis, Haramaya University, Dire Dawa, Ethiopia. 131p.

Alberro, M., 1983. Comparative performance of F1 Friesian X Zebu heifers in Ethiopia. *Animal Production Science.* 37: 247-252.

Alemayehu, M., 1985. Feed resources in Ethiopia. PP.35. In: Animal feed resources for small-scale livestock producers, Proceedings of the second PANESA workshop, held in Nairobi, Kenya, 11-15 November 1985.

Alemayehu, M., 1987. Feed Resources in Ethiopia. PP.42. In: Proceedings of the Second National Livestock Improvement Conference . Addis Ababa, Ethiopia, 11-13 February 1987. Institute of Agricultural Research.

Alemayehu, M., 1998. The Borana and the 1991-92 Drought: A Rangeland and Livestock Resource Study, Institute of Sustainable Development, Addis Ababa, Ethiopia. 102p.

Alemayehu, M., 2004. Pasture and Forage Resource profiles of Ethiopia. PP.19. Ethiopia/FAO. Addis Ababa, Ethiopia.

Alemayehu, M., 2005. Feed Resources Base of Ethiopia: Status Limitations and opportunities for Integrated development. Proceedings of the 12th Annual Conference of the Ethiopian Society of Animal Production (ESAP) held in Addis Ababa, Ethiopia, August 12-14, 2004. Addis Ababa, 410p.

Alemu, T., 1990. The Unexploited Potential of Improved Forages in the Mid-altitude and Lowland areas of Ethiopia. In: Utilization of Research Results on Forage and Agricultural By-product Materials as Animal feed resource in Africa. Proceedings of the first Joint workshop held in Lilongwe, Malawi, 5-9 December 1988. 833p.

Alemu, Y., Zinash, S. and Seyoum, B., 1989. The Potentials of Crop Residue and Agro-Industrial by-products as animal feed. PP. 57-64. Proceedings of the Third National Livestock Improvement Conference. Addis Ababa, Ethiopia, 24-26 May 1989. Institute of Agricultural Research (IAR).

Alganesh, T. Mathewos, B. and Gizaw, K., 2004. Survey on Traditional Livestock Production Systems in Manasibu District of West Wallaga, Ethiopia. PP. 151-155. In: Proceedings of the 12th annual conference of the Ethiopian Society of Animal Production (ESAP) held in Addis Ababa, Ethiopia, August 28-30, 2003.

Amsalu, S., 2000. Condition of the major grazing areas in the mid-rift valley of Ethiopia. An MSc. Thesis, Alemaya University , Dire Dawa, Ethiopia. 78p.

Anderson, F. M., 1987. Farmer circumstances in Ethiopia and the improvement of animal feed resources. PP. 40-56. In: Animal feed resources for small-scale livestock producers-Proceedings of the second PANESA, workshop held in Nairobi, Kenya, 11-15 November 1985.

AOAC, 1990, (Association of Official Analytical Chemists). Official methods of Analysis. (15th edition.), AOAC Inc, Arlington, Virginia, USA. 957p.

AOAC (Association of Official Analytical Chemists). 1995. Official Methods of Analysis. PP.5-13. (16th edition), Washington DC.

Asfaw, W., 1997. Livestock Development Policy in Ethiopia. In: Livestock development policies in Eastern and Southern Africa. Proceedings of a seminar organized by CTA, OAU/IBAR and the Ministry of Agriculture and Cooperatives, Mbabane, Swaziland. 28 July-1 August, 1997.

Ayele, S., Assegid, W., Jabbar, M., Ahmed, M and Belachew, H., 2003. Livestock marketing in Ethiopia: A review of structure, performance and development initiatives. Socio-economics and Policy Research Working Paper 52. ILRI (International Livestock Research Institute), Nairobi, Kenya. 35p.

Azage Tegegne and Alemu Gebre Wold, 1998. Prospects for peri-urban dairy development. Pp. 28-39. In: ESAP (Ethiopian Society of Animal Production), Fifth National Conference of Ethiopian Society of Animal Production, held in Addis Ababa, Ethiopia, 15-17 May 1998.

Azage, T., Million, T., Alemu, Y. and Yoseph, M., 2000. Market oriented urban and peri-urban dairy systems. Urban Agricultural Magazine (The Netherlands). PP. 23-24.

Azage, T., 2003. Financing market oriented dairy development: the case of Ada'a-Liben district Dairy Association, Ethiopia. Urban Agricultural Magazine. No. 9. Koninklijke, Netherlands. 45p.

Azage, T., 2004. Urban livestock production and gender in Addis Ababa. PP.3. Urban Agriculture Megazine, number 12, MEI, 2004. ILRI (International Livestock Research Institute). Addis Ababa, Ethiopia.

Baars, R.M.T., E.C. Chileshe and D.M. Kalokoni, 1997. Technical Note. Range Condition in high cattle density areas in the Western Province of Zambia. *Journal of Tropical Grasslands.* 31: 565-573.

Bayush, T., Adugna, T. and Trygve, B., 2008. Livestock production and feed resource constraints in Akaki and Lume Districts, Central Ethiopia. *Outlook on Agriculture.* 37(1): 15-21.

Bekele, S., 1991. Crop livestock interactions in the Ethiopian highlands and effects on sustainability of mixed farming: a case study from Ada district, Debrezeit. An MSc. Thesis Agricultural University of Norway, Oslow, Norway.163p.

Belachew, H., 1998. Milk sales outlet options in Addis and the surrounding peri-urban areas. PP. 72-81. In: ESAP (Ethiopian Society of Animal Production), Fifth national conference of the Ethiopian Society of Animal Production (ESAP) held in Addis Ababa, Ethiopia, 22–24 August 2003. ESAP, Addis Ababa, Ethiopia.

Belachew, H. and Jemberu, E., 2003. Challenges and opportunities of livestock marketing in Ethiopia. In: Jobre Y and Gebru G (eds), Challenges and opportunities of livestock marketing in Ethiopia. Proceedings of the 10th annual conference of the Ethiopian Society of Animal Production (ESAP) held in Addis Ababa, Ethiopia, 21–23 August 2002. ESAP, Addis Ababa, Ethiopia. PP. 1–13.

Belaynesh, D., 2006. Floristic Composition and Diversity of the Vegetation, Soil Seed Bank Flora and Condition of the Rangelands of the Jijiga Zone, Somali Regional State, Ethiopia. An MSc. Thesis, Alemaya University, Dire Dawa, Ethiopia. 124p.

Berhanu, G., Adane. H. and Kahsay, B., 2009. Feed Marketing in Ethiopia: Results of rapid market appraisal. Improving Productivity and Market Success (IPMS) of Ethiopian farmers project Working Paper 15. ILRI (International Livestock Research Institute), Nirobi, Kenya. 64p.

Borman, J.M., Macmillan, K.L. and Fahey, J., 2004. The potential for extended lactations in Victorian dairying: a review. *Australian Journal of Experimental Agriculture.* 44: 507-519.

Chantiratikul, A., Piyanete, C. and Chumpawadee, S., 2009. Effect of dietary Phosphorous on nutrient and Phosphorous digestibility in Thai-Indigenous X Brahma crossbred cattle. Medwell, publishing. *Journal of Animal and Veterinary Advances.* 8 (8): 1558-1562.

Chenost, M. and Sansoucy, R., 1991. Nutritional Characteristics of Tropical Feed Resources: Natural and improved Grasslands, Crop Residues and Agro-industrial By-products. FAO. *Animal Production and Health paper.* 861: 66-81.

Church, D.C. and Pond, W.C., 1982. Basic Animal Nutrition and Feeding Record. John Wiley and Sons, U.S.A. 1135p.

Coppock, D.L., 1994. The Boran Pleatue of Southern Ethiopia: Synthesis of Pastoral Research, Development and Change, 1980-91. ILCA systems study. No.5, ILCA, Addis Ababa, Ethiopia. 393p.

Crowder, L.V. and Chheda, M. R., 1982. Tropical grassland husbandry. Longman London, PP.315-316,346-352.

CSA (Central Statistical Authority). 1999. Statistical Report on the National Labour Force Survey, Addis Ababa, Ethiopia. 94p.

CSA (Central Statistical Authority). 2004. The Ethiopian Agricultural Sample Enumeration (EASE), Executive Summery, May 2004, Addis Ababa, Ethiopia.

CSA (Central Statistical Agency). 2008. Livestock and Livestock Characteristics, Agricultural Sample Survey. Volume II, Statistical Bulletin, 446, 188p.

Daniel, K., 1988. Role of crop residues as livestock feeds in Ethiopian Highlands. PP. 430-439. In: B.H. Dzzowela (eds.). Proceedings of a Workshop on African Forage Plant Genetic Resources, Evaluation of Forage Germplasm and Extensive Livestock Production Systems. Arusha, Tanzania, 27-30 April 1987.

Dematawewa, C. M. B., and P. J. Berger, 1998. Genetic and phenotypic parameters for 305-day yield, fertility, and survival in Holsteins. *Journal of Dairy Science.* 81:2700–2709.

de Vries, A. and C. A. Risco, 2005. Trends and seasonality of reproductive performance in Florida and Georgia dairy herds from 1976 to 2002. *Journal of Dairy Science. 88*:3155–3165.

De Vries, A., 2006. Determinants of the cost of days open in dairy cattle. Proceedings of the 11th International Symposium on Veterinary Epidemiology and Economics. www.sciquest.org.nz, (Accessed on August 15, 2009).

Dereje, T., Workneh, A. and Hegde, B.P., 2005. Survey of traditional cattle production systems and preferred cattle functions in North and South Wollo zones, Ethiopia. *Ethiopian Veterinary Journal.* 9: 91-108.

Debrah, S. and Berhanu, A., 1991. Dairy marketing in Ethiopia: Markets of first sale and producers' marketing patterns. ILCA Research Report 19. ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia. 21p.

Dechassa, L., 2000. Field Assessment Report: Jimma Zone of Oromia Region, 10-14 August 2000. United Nations Development Programme, UN-Emergencies Unit for Ethiopia, Addis Ababa, Ethiopia. 5p.

Demeke, S., F.W.C. Neser, S. J. Schoeman, G.J. Erasmus, J. B.Van Wyk, and A. Gebrewolde, 2000. Crossbreeding Holstein-Friesian with Ethiopian Boran Cattle in A Tropical Highland Environment: Preliminary Estimates of Additive and Heterotic Effects on Milk Production Traits. *South African Journal of Animal Science* 30 (1): 32-33.

Desalegn, G., 2008. Assessment of Problems/Constraints Associated with Artificial Insemination Service in Ethiopia. An MSc. Thesis, Addis Ababa University, Faculty of Veterinary Medicine, Ethiopia. 110p.

Ehui S., Benin, S., Williams, T. and Meijer, S., 2002. Food Security in Sub-Saharan Africa to 2002, Socio-economics and Policy research working paper 49,ILRI (International Livestock Research Institute), Nairobi, Kenya. 60p.

Ekwe, K.C., and I. Nwachukwu, 2006. Influence of household factors on the Utilization of Improved Garri Processing Technology in Southeastern Nigeria. *Journal of Agricultural. Extension* 9:134-141.

Emebet, M., 2006. Reproductive Performance of dairy Cows Under urban Dairy Production Systems in Dire-Dawa. MSc. Thesis, Alemaya University, Dire Dawa, Ethiopia. 82p.

Emiru, Z., 2007. Artificial insemination and its implementation. Ethiopian Society of Animal Production (ESAP). Addis Ababa, Ethiopia. PP. 7-14, 29, 45.

Ensminger. R.E., J.E. Oldfield, W.W. Heineman, 1990. Feed and Nutrition. (2nd edition). The Ensminger publishing company. 1151p.

Enyew, N., 1992. Reproductive performance of local and crossbred dairy cattle at the Asella livestock farm. An MSc. Thesis Alemaya University, Dire Dawa, Ethiopia. 58p.

Eric J. Underwood, 1981. The mineral nutrition of livestock. PP. 31-48. Second edition, Farnham Royal, England, CAB Publication.

FAO (Food and Agriculture Organization of the United Nations). 1984. Master Land use Plan, Ethiopia Range/Livestock Consultancy Report prepared for the Government of the People's Democratic Republic of Ethiopia. Technical Report. AG/ETH/82/010 FAO, Rome. 94p.

FAO (Food and Agriculture Organization of the United Nations). 1987. Land use, production regions, and farming systems inventory. Technical report 3 vol. 1. FAO project ETH/78/003, Addis Ababa, Ethiopia. 98P.

FAO (Food and Agricultural Organization of the United Nations). 1998. Food and Agriculture Organization 1998, Year Book. Rome, Italy.

FAO (Food and Agricultural Organization of the United Nations). 2000. Food and Agriculture Organization 2000 Year Book. Rome, Italy.

Fekadu, B., 1994. Present Situation and Future Aspects of Milk Production, Milk Handling and Processing of Dairy Products in Southern Ethiopia. Food Production Strategies and Limitations: The case of Aneno, Bulbula and Dongora in Southern Ethiopia. Department of Food Science, Agricultural University of Norway. Norway. PP.1-20.

Felleke, G. and Geda, G., 2001. The Ethiopian dairy development policy: A draft policy document. Addis Ababa, Ethiopia: Ministry of Agriculture/ AFRDRD/AFRDT. Food and Agriculture Organization/SSFF. 105p.

Foley, R. C., Bath, D. L., Dickinson, F. N. and Tucker, H. A., 1972. Dairy cattle principles, practices, problems, profits, Philadelphia, USA. 669p.

Fonteh, F.A., Mubiru, S., Tibatyungwa, F. And Lammers, W., 2005. System analysis of peri-urban smallholder dairy farming in the Lake Crescent Region of Uganda. *Livestock Research for Rural Development*. http://www.lrrd.org/lrrd/17/7/cont1707.htm. (Accessed on September 22, 2009).

Gebeyehu, G., Asmare, A. and Asseged, B., 2005. Reproductive performance of Fogera cattle and their Friesian and their crosses in Andassa ranch, Northwestern Ethiopia. *Livestock Research for Rural Development*. http://www.cipav.org.co/lrrd/lrrd 17/12/cont1712.htm. (Accessed on June 18, 2009).

Gebregziabher, G., Azage, T., Diedhion, M L. and Hegde, B P., 2005. Days to first service, conception rate and service period of indigenous and crossbred cows in relation to postpartum body weight change at Bako, Ethiopia. *Ethiopian Journal of Animal production* 5(1): 83-90.

Gebre Wold, A., Mengistu, A., Demeke, S., Bediye, S. and Tadesse, A., 2000. Status of dairy research in Ethiopia. PP.73-81. In: The role of village dairy co-operatives in dairy development. Smallholder Dairy Development Project (SDDP) Proceeding, Ministry of Agriculture (MoA). Addis Ababa, Ethiopia.

Getachew, A., Hailu, B., Werkneh, N. and Gezahegn, A., 1993. A survey of farming systems of vertisol areas of the Ethiopian highlands. PP.29-49. In: Tekalign, M., Abiye A., Srivastra, K.L. and Asgelil, D. (eds.). Improved management of vertisols for sustainable crop-livestock production in the Ethiopian highlands. Synthesis Report 1986-92. Technical committee of the joint vertisol project, Addis Ababa, Ethiopia.

Getachew, E., 2002. An Assessment of Feed Resources, Their management and impact on livestock productivity in the Ginchi watershed Area. MSc. Thesis. Alemaya University Dire Dawa, Ethiopia. 172p.

Getnet, A., 1999. Feed Resource Assessment and Evaluation of Forage Yield, Quantity and Intake of Oats and Vetches Grown in Pure Stands and in Mixtures in the highlands of Ethiopia. An MSc. Thesis, Swedish University of Agricultural Sciences. 83p.

Gibson, J., Gamage, S., Hannote, O., Iniguez, L., Maillard, J.C. Rischkowsky, B., Semambo, D. and Toll, J., 2006. Options and Strategies for the Conservation of Farm Animal Genetic Resources: Report of an international Workshop (7-10November 2005, Montpellier, France). CGIAR System-wide Genetic resources Programme (SGRP)/Biodiversity International, Rome, Italy. PP. 15-16, 35-36.

Giday, Y., 2001. Assessment of calf crop productivity and total herd life of Fogera cows at Andassa ranch in North-western Ethiopia. An MSc. Thesis, Alemaya University. Dire Dawa, Ethiopia.119p.

Girma, T., K., Sonder, Abiye, A. and D., Pedon., 2009. Improving management of livestock in Awash River basin: A challenge to Ethiopia. http://www.ilri.org/data/livelihood.htm. (Accessed on February 5, 2010).

Groenendaal, H., Galligan, D.T. and Mulder, H.A., 2004. An economic spreadsheet model to determine optimal breeding and replacement decisions for dairy cattle. *Journal of Dairy Science.* 87: 2146–2157.

Gryseels, G. and Goe, M.R., 1984. Energy flows on smallholder farms in the Ethiopian highlands. International Livestock Centre for Africa (ILCA), Bulletin, 17:2-9.

Gryseels, G., 1988. Role of Livestock on a Mixed Smallholder Farms in Debre Berhan, PhD Dissertation, Agricultural University of Wageningen, The Netherlands. 249p.

Hafez, E S E., 1993. Reproduction in Farm Animals. 6th edition Lea and Febiger, Philadelphia, USA. PP. 237-261.

Hailemariam, M. and Kassamersha, H., 1994. Genetic and environmental effects on age at first calving and calving interval of naturally bred Boran (zebu) cows in Ethiopia. *Animal Production.* 58: 329-334.

Hizkias, K. and Tsehay, R., 1995. Dairy production systems in Ethiopia. In: Proceedings of a workshop entitled: Strategies for Market Orientation of Small Scale Milk Producers and their Organizations. 20-24 March, 1995, Morogoro, Tanzania.

Hizkias K., 2000. Dairy development in Ethiopia. PP. 26-39. In: The role of village dairy co-operatives in dairy development. SDDP (Smallholder Dairy Development Project) Proceedings, MoA (Ministry of Agriculture), Addis Ababa, Ethiopia.

Holloway, G., C. Nicholson, C. Delgado, S. Staal and S. Ehui, 2000. Agro-industrialization through Institutional Innovation Transaction Costs, Cooperatives and Milk-market Development in the Eastern African Highlands. *Agricultural Economics*. 23: 279-288.

IBC (Institute of Biodiversity Conservation). 2004. The state of Ethiopia's Farm Animal Genetic Resources: A contribution to the first report on the state of the world's animal genetic resources. May 2004, Addis Ababa, Ethiopia. 90p.

Ike A., 2002. Urban dairying in Awassa, Ethiopia. MSc thesis, University of Hohenheim, Stuttgart-Hohenheim, Germany. 113p.

ILCA (International Livestock Centre for Africa). 1990. Livestock System Research manual, ILCA Working Paper No. 1, Volume 1. International Livestock Centre for Africa (ILCA), Addis Ababa, Ethiopia. 287p.

ILRI (International Livestock Research Institute). 1995 .Livestock Policy Analysis, Training Manual, Nairobi, Kenya. 264p.

ILRI (International Livestock Research Institute). 1996. Annual Project Report. ILRI, Addis Ababa, Ethiopia. 246p.

Iowga, A. B., Urid, N. A., 1987. An inventory of livestock feed resources in Tanzania. In: Proceedings of 2nd PANESA workshop held at Nairobi, Kenya, 11-15 November 1985.

James, F. Roche, 2006. The effect of nutritional management of the dairy cow on reproductive efficiency. *Animal Reproduction Science.* 96 (2006): 282-296.

JZMSR (Jimma Zone Meteorology Station Report). 2004. Ten year’s calamite data. JZMS. Jimma, Ethiopia.36p.

Kassahun, A., H.A., Synman and G.N. Smit, 2008. Impact of rangeland degradation on the pastoral production systems, livelihoods and perceptions of the Somali pastoralists in Eastern Ethiopia. *Journal of Arid Environments.* 72 (2008): 1265-1281.

Kayongo-Male, H., C.N. Karue and E. R. Mutiga, 1982. The effect of preconception supplementation on the productivity of dairy heifers grazed on medium quality pasture under East African conditions. *Bulletin of Animal Health and Production in Africa.* 30: 65-72.

Kearl, L.C., 1982. Nutrient Requirement of Ruminants in Developing Countries International Feed stuffs Institute, Utah Agricultural Experiment Station, Utah State University, Longman 84322. USA, 381p.

Kebreab, E., T.Smith, J.Tanner and P.Osuji., 2005. Review of under nutrition in smallholder ruminant production system in the tropics. In coping with feed scarcity in smallholder livestock systems in developing countries, International Livestock Research Institute, Nairobi, Kenya. PP. 3-95.

Kedija, H., 2007. Characterization of milk production system and opportunity for market orientation: A case study of Mieso district, Oromia Region, Ethiopia. An MSc. Thesis, Haramaya University, Dire Dawa, Ethiopia. 184p.

Kefena, E., 2004. Analysis of longevity, productive herd lifetime milk production of Boran crossbred cows with various level s of exotic inheritance in the central highlands of Ethiopia. An MSc. Thesis, Alemaya University, Dire Dawa, Ethiopia. 116p.

Kelay, B., 2002. Analyses of Dairy Cattle Breeding Practices in Selected Areas of Ethiopia, PhD. Dissertation, Humboldt University of Berlin, Germany.164p.

Kellems, Richard O. and Church D.C., 1998. Livestock Feeds & Feeding.(4th edition.). Prentice-Hall, Inc., New Jersey, USA. 573p.

Kiwuwa, G. H., J.C.M. Trail, M. Y. Kurtu, G. Worku, F.M. Anderson and J. Durkin, 1983. Crossbred dairy cattle productivity in Arsi Region, Ethiopia. International Livestock center for Africa (ILCA). Research report No. 11, PP. 1-29.

Knudeson, P.N. and A.S. Sohael, 1970. A study of the performance of a mixed Friesian X zebu herd in a tropical environment. *Journal of Tropical Agriculture*. 43:189-203.

Legesse, D., Gemechu, G., Tesfaye, K. and Getahun, T., 1987. Bako mixed farming zone diagnostic survey report. Wollega and Shewa regions. Department of Agricultural Economics and Farming Systems Research, Report No. 1.

Lemma, F., Fekadu, B. and P.B. Hegde, 2005. Rural Smallholders Milk and Dairy Products Production, Utilization and Marketing Systems in East Shoa Zone of Oromia. PP. 17-28. In: Proceedings of the 12th Annual Conference of the Ethiopian Society of Animal Production (ESAP) held in Addis Ababa, Ethiopia, August 12-14, 2004.

Lemma, G. and G.N. Smit, 2004. Crude protein and mineral composition of major crop residues and supplemented feeds produced Vertisols of the Ethiopian highlands. Bloemfontein, South Africa. *Journal of Animal Feed Science and Technology*. 119(2005): 143-153.

MAFF (Ministry of Agriculture Fisheries and Food). 1984. Energy allowances and feeding systems for ruminants. Reference Book 413 HMOs, London, 85p.

McCarthy, G., 1986. Donkey Nutrition. In: J.D. Reed and B.S. Capper and J.H. Neate (eds.) The professional Hand book of the Donkey (Compiled for the donkey sanctuary).Sid mouth (UK). 248p.

McDonald, P, R.A and Greenhalgh, J.F.D., 1988. Animal nutrition fourth (eds.). Longman Scientific and Technical. New York. 633p.

McDonald, P., Edwards, R.A., Greenhalgh, J.F.D. and Morgan, C.A., 1995. Animal Nutrition. (Fifth Edition). Longman Group, Harlow, United Kingdom. 607p.

McDonald, P., R. A. Edwards, J. F. D. Greenhalgh, C. A. Morgan, 2002. Animal Nutrition (6th edition). Pearson Educational Limited. Edinburgh, Harlow, Great Britain. 544p.

McDowell, R. E., 1972. Improvement of Livestock Production Under Warm Climates. WH Freeman, San Fransisco, California, USA. 711p.

McDowell, LR., 1985. Nutrition of Grazing Ruminants in Warm Climates. Orlando, FL: Academic Press. 443p.

McDowell, R.E., 1988. Improvement of Crop Residues for Feeding Livestock in Smallholder Farming Systems. PP.3-27. In: J.D. Reed, B.S. Capper and P.J.H., Neate (eds.). Plant Breeding and Nutritive Value of Crop Residues. Proceedings of a Workshop. Held at ILCA, Addis Ababa, Ethiopia, 7-10 Dec. 1987. ILCA, Addis Ababa.

McIntire, J, D. Bourzat and P. Pingali, 1992. Crop Livestock Interaction in Sub-Saharan Africa. Regional and Sectoral Studies Series. The World Bank, Washington, DC. 246p.

Meadows, C., Rajala-Schultz, P.J. and Frazer, G.S., 2005. A spreadsheet-based model demonstrating the non-uniform economic effects of varying reproductive performance in Ohio dairy herds. *Journal of Dairy Science.* 88: 1244–1254.

Mekonnen, H., 1987. Evaluation of growth and reproductive performance of Borana cattle and their crosses with Friesian at Abernossa, Shoa, Ethiopia. An MSc. Thesis Alemaya University. Dire Dawa, Ethiopia. 59p.

Mekonnen, H. and Goshu, M., 1987. Reproductive performance of Fogera cattle and their Friesian crosses. *Ethiopian Journal of Agricultural Science*. 9(2): 95-114.

Mesfin, D., Seyoum, B., Aemiro, K., Getu, K. and Kedir, N., 2009. On-farm evaluation of lactating crossbred (*Bos taurus* x *Bos indicus*) dairy cows fed a basal diet of urea treated teff (*Eragrostis tef*) straw supplemented with escape protein source during the dry season in crop-livestock production system of north Shoa, Ethiopia. *Livestock Research for Rural Development* . http://www.lrrd.org/lrrd 21/5/cont2105.htm. (Accessed on October 13, 2009).

Milford, R. and D.J.,Minson, 1966. The relation between the crude protein content and the digestible crude protein of tropical pasture plants. *Journal of the British Grassland Society.* 20: 177-183.

Million, T. and Tadelle, D., 2003. Milk production performance of Zebu, Holstein Friesian and their crosses in Ethiopia. *Livestock Research for Rural Development*. http://www.lrrd.org/lrrd 15/3/cont153. htm. (Accessed on August 17, 2009).

MoA (Ministry of Agriculture). 1997. Ruminant Livestock Development Strategy, Addis Ababa. 87p.

Moges, D. and Robert Baars, 1998. Long-Term Evaluation of Milk Production and Reproductive Performance of Dairy Cattle at Alemaya. In: proceedings of the 6th annual conference of the Ethiopian Society of Animal Production. Addis Ababa, Ethiopia, October 14-15 May 1998. PP. 176-183.

Mohamed, A., Ahmed, A., Ehui, S. and Yemesrach, A., 2003. Dairy Development in Ethiopia. Paper presented at the InWent, IFPRI, CTA, NEPAD Conference Paper No. 6, December 1-3, 2003, Pretoria.

Mohamed, A., Ahmed, A., Ehui, S. and Yemesrach, A., 2004. Dairy Development in Ethiopia. EPTD discussion paper No. 123. International Food Policy Research Institute. Washington, DC. U.S.A. 41p.

Mohammed-Saleem, M. A. and Abate, T., 1995. Feed improvement to support intensification of ruminant production systems in the Ethiopian highlands. PP. 296-306. In: Proceedings of the 3rd Annual Conference of the Ethiopian Society of Animal Production. Addis Ababa, Ethiopia, 27-29 April 1995.

Msangi, B.S.J., Bryant, M. J. and Thorne, P.J., 2005. Some factors affecting variation in milk yield in crossbred dairy cows on smallholder farms in North-east Tanzania. *Tropical Animal Health and Production.* 37: 403–412.

Mukasa-Mugerwa, E., 1989. A review of reproductive performance of female Bos indicus (Zebu) cattle. ILCA, Monograph No. 6. International Livestock Center for Africa, Addis Ababa, Ethiopia. 134p.

Mukasa-Mugerwa, E., Tegegne, A., Mesfin, T. and Teklu, Y., 1991. Reproductive efficiency of Bos indicus (zebu) cows under artificial insemination management in Ethiopia. *Animal Reproduction Science.* 24: 63–72.

Mulugeta, K., Tesfaye, K., and Gebre-Egziabher, G., 1991. Some productive and reproductive performance of Horro cattle at Bako Research Centre. PP.78-82. Proceedings of the fourth National Livestock Improvement Conference. 13-15. Nov. 1991, Addis Ababa, Ethiopia.

Mulugeta, A., Azage, T. and B.P. Hegde, 2009. Lactation Performance of Dairy Cows in the Yerer Watershed, Oromiya Region, Ethiopia. In: Proceedings of the 16th Annual Conference of the Ethiopian Society of Animal Production. Addis Ababa, Ethiopia, October 8-10, 2008. PP. 159-168.

Ngongoni, N.T., C. Mapiye, M. Mwale and B. Mupeta, 2006. Factors affecting milk production in the smallholder dairy sector of Zimbabwe, Harare, Zimbabwe. *Livestock Research for Rural Development.* http://www.lrrd.org/lrrd/lrrd 18/5/ cont1805.htm. (Accessed on January 12, 2010).

Nilforooshan, M. A. and M. A. Edriss, 2004. Effect of Age at First Calving on Some Productive and Longevity traits in Iranian Holsteins of the Isfahan Province. American Dairy Science Association. *Journal of Dairy Science.* 87:2130–2135.

Nigussie, G., 2006. Characterization and evaluation of urban dairy production system in Mekelle city, Tigray region, Ethiopia. An MSc thesis, Hawassa University, Hawassa, Ethiopia. 54p.

NRC (National Research Council), 1996. Nutrient Requirements of Beef Cattle**.** 7th Revised edition. National Academy of Science, National Academy Press: Washington, DC, USA. 234p.

Ofuoku, A.U., Egho, E. O.and Enujeke, E.C., 2009. Integrated Pest Management (IPM) adoption among farmers in Central Agro-ecological Zone of Delta State, Nigeria. *Advances in Biological Research.* 3 (1-2): 29-33.

Ojango, J. M. K. and G. E. Pollott, 2001. Genetics of milk yield and fertility traits in Holstein-Friesian cattle on large-scale Kenyan farms. *Journal of Animal Science.* 79:1742–1750.

ørskov, E. R., 1988. Consistency of differences in nutritive value of straw from different varieties in different season. In: J.D. Reed, B.S. Capper and P.J.H. Neate (eds.). PP. 163- 76. Proceedings of a Workshop on Plant breeding and Nutritive Value of Crop Residues. Addis Ababa, Ethiopia, 7-10 December 1987. ILCA.

Österman, S. and Bertilsson, J., 2003. Extended calving interval in combination with milking two or three times per day: effects on milk production and milk composition. *Livestock Production Science.* 82 (2):139-149. Uppsala, Sweden.

Otterby, D. E. and J. G. Linn, 1981. Nutritional effects on reproduction in dairy cattle. Proc. 42nd Minnesota Nutr. Confe. Minnesota, USA, p. 9.

Oyedipe, E. O., Osori D. I. K, Akerejola, O. and Saror, D., 1982. Effect of level of nutrition on onset of puberty and conception rates of zebu heifers. *Theriogenology. 18*: 525-539.

Perkin, E., 1982. Analytical Methods for Atomic Absorption Spectrophotometry. Perkin Elmer Corporation, Norwalk, Connecticut, USA.

Peters, A. R., 1984. Reproductive activity of the cow in the postpartum period. 1. Factors affecting the length of the postpartum a cyclic period. *British Veterinary Journal.* 140:76-83.

Petmak, M.V., 1983. Primary productivity, nutrient cycling and OM turnover of tree plantation after agricultural intercropping practices in northeast Thailand. PhD. Dissertation, University of Philadelphia, Los Banos, Philadelphia. 228p.

Preston, T. R. and Leng, R. A., 1984. Supplementation of diets based on fibrous residues and by-products as feed. Elsevier Science Publishing Company, INC. New York, PP. 373-453.

Ramazin, M., E.R. Ørskov, and A.K. Tuah, 1986. Degradation of Straw: Botanical Fractions of Straw from two Barley cultivars. *Animal Production Science.* 43: 271-278.

Reed, J.D., Yilma, K. and L.K. Fossel, 1986. Factors affecting the Nutritive value of sorghum and millet crop residues. In: J.D. Reed, B.S. Capper and P.J.M.Neate (eds). Plant breeding and the nutritive value of crop residues. Proceedings of ILCA, workshop held at Addis Ababa, Ethiopia. PP. 233-251.

Ruiz-Sanchez, R., R.W. Blake, H.M.A. Castro-Gamez, F. Sanchez, H.H. Montaldo and H. Castillo-Juarez, 2007. Changes in the association with between milk yield and age at first in Holstein cows with herd environment level for milk yield. *Journal of Dairy Science.* 90:4830-4834. American Dairy Science Association.

SAS., 2002. Statistical Analysis System software, Version 9.0, SAS Institute, Inc., Cary, NC, USA.

Schillo, K. K., J. B. Hall and S. M. Hileman, 1992. Effects of nutrition on season and onset of puberty in the beef heifer. *Journal of Animal Science.* 70:3994-4005.

Seyoum, B. and Zinash, S., 1988. Feeding value of some Ethiopian feedstuffs. PP.175-185. IAR Proceedings, Second National Livestock Improvement Conference. 24-26 February.1988. Addis Ababa, Ethiopia.

Seyoum, B., Zinash, S., Tadesse, T. and Liyusew, A., 1997. Evaluation of Napier (Pennisetum purpureum) and Pennisetum hybrids (Pennisetum purpureum X Pennisetum typhoides) in the central highlands of Ethiopia. PP. 194-202. In: Proceedings of the Fifth National Conference of the Ethiopian Society of Animal Production (ESAP). 15-17 May 1997, Addis Ababa, Ethiopia.

Seyoum, B., Getinet, A., Abate, T. and Dereje, F., 2001. Present status and future direction in feed resources and nutrition research targeted for wheat based crop livestock production system in Ethiopia. PP. 207-226. In: P. C. Wall (eds.). Wheat and Weed Food and Feed. Proceedings of Two Stakeholder Workshops. CIMMYT, Mexico City. Improving the productivity of Crop Livestock Production in Wheat-based Farming Systems in Ethiopia, Addis Ababa, Ethiopia, 10-11 October 2000.

Seyoum, B., Zinash, S. and Dereje, F., 2007. Chemical Composition and Nutritive Values of Ethiopian Feeds.Research Report 73, Ethiopian Institute of Agricultural Research (EIAR), Addis Ababa, Ethiopia. 24p.

Seyoum, B. and Fekede, F., 2008. The status of animal feeds and nutrition in the West Shewa Zone of Oromiya, Ethiopia. PP. 27-49. In: Proceedings of the Workshop 'Indigenous Tree and Shrub Species for Environmental Protection and Agricultural Productivity', November 7-9, 2006, Holetta Agricultural Research Centre (HARC), Ethiopia. Series on Conference and Workshop Proceedings of KEF (Commission for Development Studies at the Austrian Academy of Sciences): 2008/1.

Short, R E., Bellows, R A., Staigmillor, R B., Berdinelli J G. and Custer, E., 1990. Physiological mechanisms controlling anoestrus and infertility in postpartum beef cattle. *Journal of Animal Science*. 68: 799-816.

Singh, G.P. and Oosting, S. J., 1992. A Model for Describing the Energy Value of Straws. Indian Dairyman XLIV. PP. 322-327.

Sintayehu, Y., Fekadu, B., Azage, T. and Berhanu, G., 2008. Dairy production, processing and marketing systems of Shashemene, Dilla area, South Ethiopia. IPMS Improving Productivity and Market Success) of Ethiopian Farmers Project Working Paper 9. ILRI (International Livestock Research Institute), Nairobi, Kenya. 62p.

Sisay, A., 2006. Livestock Production Systems and Available Feed Resources in Different Agro-ecologies of North Gonder Zone, Ethiopia. M.Sc. Thesis, Alemaya University, Dire Dawa, Ethiopia. 95p.

Solomon, B., 2004. Assessment of Livestock Production Systems Feed Resource base in Sinana Dinsho district of Bale highlands, Southeast Oromya, An MSc. Thesis, Alemaya University, Dire Dawa, Ethiopia.

Solomon, B., Solomon, M. and Alemu, Y., 2008a. Influence of rainfall pattern on grass/legume composition and nutritive value of natural pasture in Bale Highlands of Ethiopia. *Livestock Research for Rural Development*. http://www.cipav.org.co/lrrd/lrrd20/3/ cont2003.htm. (Accessed on July 21, 2009).

Solomon, B., Solomon, M. and Alemu, Y., 2008b. Potential Use of Crop Residues as Livestock Feed Resources Under Smallholder Farmers Conditions in Bale Highlands of Ethiopia. PP. 107-114. *Tropical and Subtropical Agro-ecosystems.* Universidad, Autónoma de Yucatán, Yucatán, México.

Streeter, S., 2006. Feeding livestock in temporary holding facilities in the Northern Territory, Australia. http://www.nt.gov.au/d/Content/File/p/Anim_Man/831. pdf. (Accessed on October 20, 2009).

Sutton, J. D., Aston, K., Beever, D. E. and Dhanoas, M. S., 1996. Milk production from silage based diets: effect of high-protein concentrates for lactating heifers and cows on intake, milk production and milk nitrogen fractions. *Journal of Animal Science.* 62:207-215.

Syrstad, O. and Ruane, J., 1998. Prospects and strategies for genetic improvement of the dairy potential of tropical cattle by selection. *Tropical Animal Health and Production.* 30 (1998): 257-268.

Tadesse, B. and Zelalem, Y., 2004. Feeding noug '*Guizotia abyssinica*' cake as protein source to lactating Borana X Jersey crossbred cows: performances in milk yield, reproduction and feed efficiency. PP. 375-385. In: Farm animal biodiversity: status and prospects. Proceedings of the 11th Annual Conference of the Ethiopian Society of Animal Production (ESAP). 28-30 August 2003, Addis Ababa, Ethiopia.

Tadesse, B., 2005. Calf Sex Ratios in Artificially Inseminated and Natural Mated Female Crossbred Dairy Herd. In: proceedings of the 13th annual conference of the Ethiopian Society of Animal Production. Addis Ababa, Ethiopia, PP. 225-230.

Tawah, C. L., Mbah, D. A., Messine, O., Enoh, M. B.and Tanya, V. N., 1999. Crossbreeding cattle for dairy production in the tropics: effects of genetic and environmental factors on the performance of improved genotypes on the Cameroon highlands. *Journal of Animal Science.* 69: 59-67.

Taylor, M., 1984. Assistance of land use planning in Ethiopia. Livestock and feed resources; Technical report No.6. FAO, Rome. 71p.

Teferi, A., 2006. Identification and Nutritional Characterization of Major Browse Species in Abergelle Woreda of Tigray, Ethiopia. MSc. Thesis Alemaya University, Dire Dawa, Ethiopia. 75p.

Tesfaye, A., 1990. Livestock development in the peasant sector of highland of Ethiopia: Some policy issues and implications. In: African Livestock Policy Analysis Network (ALPAN), Network paper No 24, June, 1990, ILCA, Addis Ababa, Ethiopia. http://www.fao.org/wairdocs/ilri. htm. (Accessed on July 10, 2008).

Teshome, A., 2007 Traditional Utilization Practices and Condition Assessment of Rangelands in Rayitu District of Bale Zone, Ethiopia. An M.Sc. Thesis, Haramaya University, Ethiopia. 128p.

Tessema, Z., Aklilu, A. and Ameha, S., 2003. Assessment of the livestock production system, available feed resources and marketing situation in Belesa Woreda: A case study in drought prone areas of Amhara Region. PP. 165-175. In: Proceedings of the 10^{th} annual conference of the Ethiopian Society of Animal Production (ESAP) held in Addis Ababa, Ethiopia, August 22-24, 2002.

Topps, J. H and Oliver, J., 1993. Animal foods of Central Africa. Zimbabwe Agricultural Journal, Technical Handbook, No. 2. Zimbabwe, Harare. 154p.

Tothill, J.C., 1987. Fodder and Forage Management for Smallholder Mixed Farmers in the Ethiopian highlands. ICIMOD Conference on Mountain Pasture and Fodder Management in the Hindus Region, Kathamandu, Nepal 25-31, May 1987. 21p.

Tozer, P. R. and A. J. Heinrichs, 2001. What affects the costs of raising replacement dairy heifers; a multiple-component analysis. *Journal of Dairy Science.* 84:1836-1844.

Tsehay, R., 1997. Milk processing and marketing options for rural small scale producers. PP. 28-39. In: Proceedings of the fifth national conference of the Ethiopian Society of Animal Production (ESAP). 15-17 May, 1997, Addis Ababa, Ethiopia.

Tsehay, R., 2002. Small-scale milk marketing and processing in Ethiopia. PP.352-367. In:Smallholder dairy production and market opportunity and constraints. Proceeding of a south-south workshop held at NDDB, Anand, India, 13-16 march 2001. NDDB (National Dairy Development Board), Anand, India, and ILRI (International Livestock Research Institute), Nairobi, Kenya.

Tsigeyohannes, H., 2000. Livestock feed security and associated impacts on sustainable agricultural development. PP. 51-61. In: Proceedings of the 7th Annual Conference of the Ethiopian Society of Animal Production (ESAP) held in Addis Ababa, 26-27 May 1999.

Van Soest, P. J., 1982. Nutritional Ecology of the Ruminants: Ruminant metabolism, Nutritional strategies, the cellulolytic Fermentation and the Chemistry of Forages and Plant Fibers. Ithaca, New York. 373p.

Van Soest, P. J. and Robertson, J.B., 1985. Analysis of Forages and Fibrous Foods. A Laboratory Manual for Animal Science 613. Cornel University, Ithaca. New York, USA, 202p.

Verjux, E., 1988. Relationships between cereals and forage cropping in the Eastern Hararghe Highlands of Ethiopia, Farming systems research, Alemaya University.

Vernooij, A.G., 2007. Report Ethiopia Mission, 22-29 September, 2007. Internal Report 200706. Animal Sciences Group, Wageningen University.

Wilson, P.N. and Brigstocke, T.D.A., 1983. Improved feeding of cattle and sheep. A practical guide to modern concepts of ruminant nutrition. Grenada Publishing, Great Britain. 238p.

Winrock International. 1992. Assessment of animal agriculture in sub-Saharan Africa. Winrock International Institute for Agricultural Development, Morrilton, Arkansas, USA. 125p.

Workneh, A. and J.Rowlands, 2004. Design, execution and analysis of the livestock breed survey in Oromiya regional State, Ethiopia. OADB (Oromiya Agricultural Development Bureau), Addis Ababa, Ethiopia, and ILRI (International Livestock Research Institute), Nairobi, Kenya. 260p.

Yeshitila, A., 2008. Efficiency of livestock feed resources utilization and forage development in Alaba Woreda, Southern Ethiopia. MSc. Thesis, Haramaya University, Dire Dawa Ethiopia. 128p.

Yihalem. D., 2004. Assessment of Botanical Composition and Stage of Harvesting of Selected Natural Pasture for Optimum Utilization as Hay at Andassa Livestock Research Center, Northwestern Ethiopia. An MSc Alemaya University, Dire Dawa, Ethiopia. 74p.

Yitaye, A., 1999. Livestock production systems, Feed Resources and Feed Allocation Practices in three Peasant Associations of the Awassa Woreda. An MSc Thesis Alemaya University, Dire Dawa, Ethiopia. 99p.

Yitaye, A., Maria, W., Azage, T., and Wemer, Z., 2007. Urban and peri- urban farming systems and utilization of the natural resources in the North Ethiopian Highlands. PP.5. Conference on International Agricultural Research for Development, University of Kassel-Witzenhausen and University of Göttingen, October 9-11, 2007, Germany.

Yitaye, A., 2008. Characterization and analysis of the urban and peri-urban dairy production systems in the North Western Ethiopian highlands. PhD, Dissertation, Boku University, Vienna, Austria. 120p.

Yoseph, M., 1999. Impact of feed resources on productive and reproductive performance of dairy cows in the urban and peri-urban dairy production system in the Addis Ababa milk shed and evaluation of non- conventional feed resources using sheep. An MSc. Thesis, Alemaya University, Dire Dawa, Ethiopia. 197p.

Yoseph, M., Azage, T., Alemu, Y. and N.N. Ummuna, 2003a. Variations in nutrient intake of dairy cows and feed balance in urban and peri-urban dairy production systems in Ethiopia. PP. 177-184. In: Proceedings of the 10th annual conference of the Ethiopian Society of Animal Production (ESAP) held in Addis Ababa, Ethiopia, August 22-24, 2002.

Yoseph, M., Azage, T., Alemu, Y. and N.N. Ummuna, 2003b. Milk Production, milk composition and body weight change of crossbred dairy cows in urban and peri-urban dairy production systems in Ethiopia. PP. 185-192. In: Proceedings of the 12th annual conference of the Ethiopian Society of Animal Production (ESAP) held in Addis Ababa, Ethiopia, August 22-24, 2002.

Yoseph, M., Azage, T., Alemu, Y., N.N. Ummuna, I.V. Nsahlai, 2003c. Effect of supplementation of grass hay with non-conventional agro-industrial by-products on rumen fermentation characteristics and microbial nitrogen supply in rams. *Journal of Small Ruminant Research.* 50(2003) 141-151.

Zegeye, Y., 2003. Imperative and Challenges of Dairy Production, Processing and Marketing in Ethiopia. PP. 61-67. Proceedings of the 10th annual conference of the Ethiopian Society of Animal Production (ESAP) held in Addis Ababa, Ethiopia, August 22-24, 2002.

Zinash, S. and Seyoum, B., 1989. Utilization of Feed Resources and Feeding Systems in the Central zone of Ethiopia. PP. 129-132. In: Proceedings of the Third National Livestock Improvement Conference. Addis Ababa, Ethiopia, 24-26 May 1989. IAR.

Zinash, S., Seyoum, B., Lulseged, G. and Tadesse, T., 1995. Effect of harvesting stage on yield and quality of natural pasture in the central highlands of Ethiopia. PP. 316-322. In : proceedings of the Ethiopian Society of Animal Production (ESAP); Third National Conference 27-29 April 1995. IAR, Addis Ababa, Ethiopia.

Zinash, S., Aschaew, T., Alemu, Y. and Azage, T., 2001. Status of livestock research and development in the highlands of Ethiopia. PP. 227-250. In: P.C. Wall (eds.). Wheat and Weeds: Food and Feed. Proceeding of two stockholder workshops. Mexico City, Mexico, 10-11 Oct. 2000, CIMMYT.

8. APPENDICES

Appendix Table 1 Conversion factors of livestock number to Tropical Livestock Unit (TLU)

Livestock species	TLU
Local oxen/bulls	1.1
Cross bred oxen/bulls	1.9
Local cows	0.8
Crossbred cows	1.8
Local heifers	0.5
Crossbred heifers	0.7
Local calves	0.2
Crossbred calves	0.4
Sheep	0.1
Goats	0.1
Horses	0.8
donkeys	0.5

Source: Gryseels (1988) and Bekele (1991), TLU=Total Livestock Unit.

Appendix Table 2 Total daily nutrient requirement of livestock per livestock species

Livestock species	DM (kg)	CP(g)	ME (MJ)
Oxen	4.8	361.3	33.0
Bulls	4.8	361.3	33.0
Cows	4.4	227.8	29.7
Heifers	3.3	232.0	21.7
Calves	1.9	144.0	13.0
Sheep	0.65	53.0	4.3
Goats	0.64	49.0	5.0
Horses	5.3	400.4	27.6
Donkeys	2.5	192.5	14.9

Source: Kearl (1982) and McCarthy (1986)

Appendix Table 3 Questionnaires used

<u>Section I</u>

General Information

1. Date---
2. Region---
3. Zone------------------------------------
4. Woreda-------------------------------
5. PA`S name---
6. Name of house holder---
7. Sex---
8. Age--
9. How many family members do you have?

A) Male----------------------------

B) Female------------------------

C) Children (≤ 14 years)---

D) Adult (≥15-64 years)---

E) Dependants (>65 years) ---

10. Educational status

A. Illiterate --------------------

i. Owner-----------------

ii. Spouse-----------------

iii. Children---------------

iv. Other (specify)-----------------

B. Read and write only-------------------------------

i. Owner-----------------

ii. Spouse-----------------

iii. Children---------------

iv. Other (specify)-----------------

C. Primary school------------------------------------

i. Owner-----------------

ii. Spouse-----------------

iii. Children---------------

iv. Other (specify)-----------------

D. Junior Secondary School--------------------------

i. Owner-----------------

ii. Spouse-----------------

iii. Children---------------

iv. Other (specify)-----------------

E. Secondary School----------------------------------

i. Owner-----------------

ii. Spouse-----------------

iii. Children---------------

iv. Other (specify)-----------------

F. Above Secondary School------------------------------------

i. Owner-----------------

ii. Spouse-----------------

iii. Children---------------

iv. Other (specify)-----------------

11. Land holding and land use system

A. Total area of land owned by the household----------------------------------ha

B. Food crop production----------------------------------ha

C. Grazing land----------------------------------ha

D. Fallow land------------------------------------ha

E. Forage crop production----------------------------------ha

F. Forest and woodland---ha

G. Rented/contracted land--ha

H. Other (specify)---

12. Land utilized for major types of food crops

a. Wheat---ha.

b. Barley---ha.

c. Tef --ha

d. Broad bean--ha

e. Field Pea --ha

f. Haricoat bean --ha

g. Chick pea --ha

h. oil seed (lean seed rapeseed etc.) --ha

i. Maize--ha

j. Sorghum--ha

k. Others (specify)--ha

13. Grain yield obtained from major crops

a. Wheat---Quintal.

b. Barley---Quintal.

c. Tef --Quintal

d. Broad bean--Quintal

e. Field Pea --Quintal

f. Haricot bean -- Quintal

g. Chick pea -- Quintal

h. oil seed (lean seed rapeseed etc.) -------------------------------------Quintal

i. Maize-- Quintal

j. Sorghum-- Quintal

k. other-- Quintal

14. Livestock production

Cattle herd structure

Type of animal	Total
Milking cows	
Dry cows	
Oxen	
Calves male	
Calves female	
Heifers	
Bulls	

Sheep and goats

Type of animal	Total
Ewe	
Ram	
Lamb	
Does	
Billy	
Bucks	
Kids	

Equines

Type of animal	total
Mare	
Stallions	
Pony	
Jennys	
Jack	
Foals	

15. Purpose of keeping cattle

a. Traction, yes-----------, no-------------

b. Milk, yes-----------, no-----------------

c. Both traction and milk, yes----------------- no,--------------

d. Savings, yes------------- no,----------------------

e. Other (specify) ----------------

16. Labor division of the family member in livestock management activities

Type of activities	Sex of individuals	Age of individuals
Milking		
Pregnant cow feeding and caring		
Calf rearing		
Heifer rearing		
Bull feeding		
Cattle Herding		
Barn cleaning		
Herd feeding/watering		
Milk and milk product marketing		
Feed collection		

Section II.

Dairy cattle Production and Reproduction

1.For how long did you involve in dairying?

a. Last 10 years-------------------------------

b. Last five years------------------------------

c. Last two years--------------------------

2. what type of dairy breeds do you have?

a. local

b. cross

c. Pure (full exotic)

d. combination of the above

3. What is the total number of milking cows do you have currently?

a. Local cows---------------------------------

b. Cross breed-------------------------------

c. pure exotic breed------------------------

4. Milking frequency per day

a. once per day

b. twice per day

c. thrice per day

5. Milking times

a. morning

b. early afternoon (13:00-14:00 Pm)

c. evening

6. What is the total amount of milk yield per day?

a. local cows--.(liter/day/cow)

b. crossbred cows---------------------------------(liter/day/cow)

c. Pure exotic cows-----------------------------------(liter/day/cow)

7. Lactation length for crossbred cows--- days/months and for local cows---days/months

8. Age at first calving for local heifers--years/months

9. Age at first calving for crossbred (pure exotic breed) heifers---years/months

10. Calving interval for local bred cows---------------------------------------months/year

11. Calving interval for crossbred (pure exotic bred) cows---months/year

12. Maximum number of Parity for local cows-----------------------------------

13. Maximum number of Parity for crossbred (pure bred) cows---------------------------

14. For how long does your local cow survive? ------------------------years

15. For how long does your crossbred (pure bred) cow survive? ------------------------years

16. What is the maximum productive age of your local bred cows? ---------------years

17. What is the maximum productive age of your crossbred (pure bred) cows? --------------years

18. What is the age of first mating for local bred heifers? ---------------years

19. What is the age of first mating for crossbred (pure bred) heifers? ---------------years

20. How do you breed your dairy animals?

a. using natural mating (breeding bulls)

b. AI

21. If natural mating is used where is the source of the breeding bull?

A. Reared at home B. Purchased C. Offices of Agriculture and agricultural research

22. At what parity do you expect maximum milk yield?

A. Between 1 and 2 parities B. Between 3-5 parities C. ≥6 parities.

23. At what parity do you expect better calf growth?

A. Between 1 and 2 parities B. Between 3-5 parities C. ≥6 parities.

24. For what purpose do you use crossbred (purebred exotic) male calves?

A. breeding B. selling at early age C. slaughtered at early age D. for traction

25. Way of disposing older animals

A. fattened and sold at market B. sold without finishing at market C. slaughtered at home without finishing D. slaughtered at home after fattening

26. Where did you get dairy cows initially?

A. bought from market B. obtained from the respective agricultural offices C. bred at home from AI service D. other (specify)-------------------------

27. How much do you cost to buy:

a. crossbred cows-------------------------------------birr and local cows---------------------------birr

b. crossbred heifer-------------------------------------birr and local heifer-------------------------birr

c. crossbred female calf------------------------------birr and local calf----------------------------birr

d. breeding bull--birr

e. Male breeding calf--birr

f. pure exotic cow---birr

g. pure exotic heifer---birr

h. pure exotic female calf---birr

Section III

Feeding management of animals

1. How do you feed your dairy animals?

a. indoor feeding (confined in a house) using individual feeding system

b. in a collection yard using group feeding

c. let to graze in a grazing land (grazing in an improved forage pasture land, natural pasture land or both?

d. tethering in a grazing land

e. other specify

2. if your cows are fed indoor, can you list the major types of feed you have provided to them?

----

3. Do you have access to grazing land? 1. Yes 2. No

4. If you let your dairy cows to graze, for how long do they graze per day? ------------------- hours

5. What is the size of your grazing land? --ha

a. is the grazing land your own or contracted?

---

b. if your own, how many ha?-- and if contracted how many ha? ---

6. If your cows are confined, do you know the amount of each feed type given to them daily?

a. yes

b. No

7. And if yes what is the amount of :

a. hay --kg

b. supplement: i. nouge cake-----------------------------kg/day/cow

ii. cotton seed cake----------------------------kg/day/cow

iii. wheat bran-----------------------------kg/day/cow

iv. wheat middling----------------------------------kg/day/cow

v. silage---kg/day/cow

vi. molasses --------------------------------------kg/liter/day/cow

vii. Others (specify)---

8. Do you believe that are your cows getting sufficient feed?

a. Yes

b. No

9. And if No, why?

____

____

____

10. What do you feed animals at different months?

Feeding management	Months											
	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Grazing own pasture												
Grazing communal land												
Grazing on crop residue												
Crop aftermath grazing												
Zero grazing												
Weeds from crop farms												

11. Is the grazing resource adequate to your animals?

a) Yes b) No

If not what measures do you take to alleviate problems of feed shortage?

a) Purchase concentrate b) Purchase forage (rent grazing land) c) use crop residues d) reduction of stock e) other (specify)--------------------------

12. At which season do you face feed shortages?

A) Short rainy season B) Long rainy season C) Short dry season D) Long dry season

13. What are the major consequences of feed shortages?

A) Weight loss of animals B) Reduced milk yield C) Increased mortality D) Abortions E) Animals remain unproductive for longer period F) Do not come in heat G) Others (specify)

14. Do you plant improved forage crops?

a) Yes b) No

15. If you do not plant improved forage crops, what is your reason?

a) shortage of land b) shortage of capital c) shortage of improved forage seeds d) difficult topography e) poor soil fertility and drainage f) no awareness about it g) I have no interest g) others (specify)---

16. Do you feed crop residues to your animals? a) Yes b) No

17. List the major types of crop residues you feed to your animals in your area?------------------

----

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18. What is the source of crop residues?

a) Purchased b) produced on farm c) obtained as gift d) other (specify)

19. If purchased what is the estimated price per bale or kg? It is----------------birr

20. How do you store crop residues?

a) stacked outside b) stacked under shade c) baled outside d) baled under shade e) other (specify)

21. For how long do you store crop residue before feeding?

a) soon after collection b) one month after collection c) two months after collection d) Over two months after collection

22. In what form do you feed your crop residue?

a) whole b) chopped c) treated d) mixed with other feeds e) other (specify)-----------------

----

23. What type of grazing system employed during dry season?

a) un herded b)herded c) paddock d) tethered e) zero grazing f) other (specify)

24. What type of grazing system employed during wet season?

a) un herded b)herded c) paddock d) tethered e) zero grazing f) other (specify)

25. Do you use irrigation?

A) Yes B) No

26. If yes which products do you produce with it?

a) food crops b) animal feeds c) both d) mainly food crops then crop residues e) Vegetables and vegetable residues as animal feed f) other (specify)

27. Do you feed your animals fodder trees?

A) Yes B)No

28. What type of fodder trees do you use for your animals?

A) Introduced fodder trees B) Indigenous fodder trees

29. List the names of browse trees in order of importance for livestock feed ---------------------
----
----

30. When do you feed fodder trees?

A) dry season B) Wet season C) short rainy season

31. Which part of the fodder trees would be provided to your animal?

A) leaves B) twigs C) stems D) roots

32. In what form do you feed fodder trees to your animals?

A) fresh as soon as cut B) by letting to wilt C) by drying it D) other (specify)----------

33. Do you feed hay to your animals?

A) Yes B) No

34. If yes where does the source of hay?

A) home grown B) purchased from the market

35. How do you know the quality of hay? Can you tell us some of the quality parameters helpful to judge good quality hay?

A) color B) appearance C) maturity D) species of forage/grass type E) smell F) other (specify)

36. For which group of animal do you feed hay?

A) oxen B) milking cows C) dry cows D) young calves E) breeding bulls F) young bulls and heifers

37. What is the estimated amount of concentrate and conventional feed do you buy annually?

A) Wheat bran______________________ Quintal/kg

B) Wheat middling______________________ Quintal/kg

C) Nouge cake______________________ Quintal/kg

D) Cotton seed cake______________________ Quintal/kg

E) Lean seed cake______________________ Quintal/kg

F) Rape seed cake______________________Quintal/kg

G) Molasses ______________________ litre/kg

H) Conventional feeds like byproducts of local alcoholic drinks__________________ litre/kg

Section IV

Watering Management

1. What are the sources of water to your animals?

A) River B) Pond C) Spring water D) Pipe water E) Other (specify)

2. What is the average distance travelled by livestock to the water source (point) during dry season?

A) Watered at home B) < 1km C) 1-5km D) 6-10km E) >10km

3. How frequently cattle are watered during dry season?

A) Once in a day B) Twice in a day C) A*d libitum* D) Once in two days E) Once in three days F) other (specify)------------------------------

4. How frequently shoats are watered during dry season?

A) Once in a day B) Twice in a day C) A*d libitum* D) Once in two days E) Once in three days F) other (specify)------------------------------

5) How frequently equines are watered during dry season?

A) Once in a day B) Twice in a day C) A*d libitum* D) Once in two days E) Once in three days F) other (specify)------------------------------

Section V

Milk and milk products marketing

1. How milking is done?

a. Hand milking

b. Machine milking

2. Do you practice milk selling?

a. Yes b. No

3. If yes where do you sell milk?

a. To local market b. To milk collection center

4. How do you transport milk to market?

a. By vehicle b. by cart horses or donkeys c. by loading directly on horse or donkey back d. by bicycle e. transported by the owner labor

5. How far do you travel to reach market/milk collection center? Estimated distance-------------------------------------km.

6. How long do you travel to reach market/milk collection centers?

a. By vehicle, ----------------------------------minute/hour

b. Travel on foot by holding milk------------------------- minutes/hour

c. Travel by pack animals----------------------------------minutes/hours

d. Travel by cart-horse/donkey-----------------------------minutes/hours

e. Travel by bicycle-------------------------------------minutes/hours

7. In what form do you process milk?

a. butter

b. Yoghurt

c. Cheese

d. Whey

8. At what season of the year do you get more milk?

a. dry season

b. wet season

c. short rain season

9. At what season of the year do you sell more amount of milk?

a. dry season

b. wet season (long rainy season)

c. short rain season

10. What is the price per litre/kg of whole milk during;

a. dry season----------------------------birr

b. wet season(long rainy season)-------------------------------birr

c. short rainy season-------------------------------birr

11. What is the price per kg of butter during;

a. dry season----------------------------birr

b. wet season(long rainy season)-------------------------------birr

c. short rainy season-------------------------------birr

12. What is the price per litre/kg of yoghurt during;

a. dry season----------------------------birr

b. wet season(long rainy season)-------------------------------birr

c. short rainy season-------------------------------birr

13. What is the price per litre/kg of whey during;

a. dry season----------------------------birr

b. wet season(long rainy season)-------------------------------birr

c. short rainy season-------------------------------birr

14. What is the price per kg of cheese during;

a. dry season----------------------------birr

b. wet season(long rainy season)-------------------------------birr

c. short rainy season-------------------------------birr

15. During which holidays do you sell more milk and milk products with better price? List in order---

----

16. At what season of the year do you get the lowest milk yield?

A. Dry season, B. Wet season, C. Short rainy season