ADDIS ABABA UNIVERSITY
FACULTYOF VETERINARY MEDICINE

ASSESSMENT OF THE FEEDING SYSTEMS AND FEED RESOURCES OF DAIRY CATTLE IN LEMU-BILBILO WEREDA DAIRY PRODUCTS-PROCESSING COOPERATIVES, ARSI ZONE OF OROMIA REGIONAL STATE, ETHIOPIA

BY

TEKLAY ASGEDOM TEFERI

JUNE 2008

DEBRE ZEIT-ETHIOPIA

ADDIS ABABA UNIVERSITY
FACULTYOF VETERINARY MEDICINE

ASSESSMENT OF THE FEEDING SYSTEMS AND FEED RESOURCES OF DAIRY CATTLE IN LEMU-BILBILO WEREDA DAIRY PRODUCTS-PROCESSING COOPERATIVES, ARSI ZONE OF OROMIA REGIONAL STATE, ETHIOPIA

A Thesis Submitted to School of Graduate Studies of Addis Ababa University, Faculty of Veterinary Medicine in Partial Fulfillment of the Requirements for the MSc Degree, In Tropical Animal Health and Production

BY

TEKLAY ASGEDOM TEFERI

JUNE 2008
DEBRE ZEIT-ETHIOPIA

APPROVAL SHEET

ASSESSMENT OF THE FEEDING SYSTEMS AND FEED RESOURCES OF DAIRY CATTLE IN LEMU-BILBILO WEREDA DAIRY PRODUCTS-PROCESSING COOPERATIVES, ARSI ZONE OF ROMIA REGIONAL STATE

BY

TEKLAY ASGEDOM TEFERI

BOARD OF EXAMINERS	**SIGNATURE**
1. Professor Shiban Kahr	______________
2. Dr.Adugna Tolera	______________
3. Dr. Tesfaye Kumsa	______________

ACADEMIC ADVISORS:	**SIGNATURE**
1. Dr. KELAY BELIHU ADVISOR (PhD)	______________
2. Dr. BERHAN TAMIR CO-ADVISOR (PhD)	______________

DEDICATION

I dedicate this thesis manuscript to my father; Asgedom Teferi and my mother Awetash Nerie, for the foundation they laid in the success of my life, and my wife W/ro Regbe Kassahun who sacrificed all her time, love and benefits for my success.

ACKNOWLEDGEMENT

First and for most, I would like to extend my unshared thanks to the almighty God for his mercy and providing me with the opportunity, all best endeavors, patience during my study and success in my life. I am highly indebted to express my heart felt and sincere gratitude to my major research advisor Dr. Kelay Belihu for his unreserved help, technical guidance, intellectual advise, critic and valuable assistance in the preparation and materialization of this paper. My special gratitude is also extended to my co-advisor Dr. Berhan Tamir for his valuable critics and technical assistance.

I would like to covey my especial thanks to IAR stuff members especially Ato Dreje Fikadu for his unreserved technical help. Dr.Abera Dresa State Minister is also highly appreciable for allowing the research fund/finance, FVM is also acknowledged for the financial help, where as Kulumsa research center for technical assistance.

My thanks also go to my highly be-loved wife W/ro Regbe Kassahun and son Eyob Teklay; for their patience of being lonely during my study. Moreover, I am highly indebted to the 151 sample respondents and other individuals that rendered me with assistances.

The contribution of my colleagues and stuff members especially Ato Hailemeskel Gemechu College Dean, Ato Belay Yebo Melo, Research Extension and Publication Head, Ato Ayalneh Mulate, W/ro Mulu Weldu, Ato Terefe Banti, that helped me in logistics facility, creating conducive working condition, moral and material assistance (encouragement), Aklilu Jemal (car driver) who served me with full of devotion and Zewdnesh Brhanu for her tireless home service through out my research work is ever unforgettable.

W/t Wubidile Alemayehu and W/t Mulu Biya Brhanu also deserve special thanks for their tireless assistance in typing the manuscript since the thesis write up.

Last but not least, I would also like to express my special thanks to some of my colleagues at Bekoji ATVET College for their encouragement; ATVET department stuff members, particularly Brhane Giday, and Gashaw Geda for their assistance in obtaining material;

TABLE OF CONTENTS PAGES

LIST OF TABLES IN THE TEXT

LIST OF FIGURES IN THE TEXT

LIST OF FORMATS AND TABLES IN THE ANNEX

LIST OF ABBREVATIONS AND ACRONYMS

^{0}C	Degree centigrade
AAU	Addis Ababa University
ADF	Acid detergent fiber
AI	Artificial insemination
ATVET	Agricultural Technical Vocational Education and Training
AZFEDO	Arsi zone finance and economic development office
BATVET	Bekoji Agricultural Technical Vocational Education and Training
Ca	Calcium
CF	Crude Fibre
CP	Crude Protein
DCP	Digestible Crude Protein
DM	Dry matter
DMD	Dry matter digestibility
DMY	Dry matter yield
DOMD	Digestive organic matter in dry matter
DWR	Dry weight rank
DW	Dry weight
EEF	Ether Extract Fraction
FAO	Food and Agriculture Organization
FNE	Forage Net work in Ethiopia
FVM	Faculty of Veterinary Medicine
FW	Fresh weight
GDP	Gross Domestic Product
GTDW	Grand total dry weight
Ha	Hectare
Hrs	Hours
IAR	Institute of Agricultural research
ILCA	International livestock center for Africa
ILRI	International livestock institute
IVDMD	In-Vitro Dry Matter Digestibility

KARC	Kulumsa Agricultural research center
Kg	Kilogram
Km	Kilometer
LBWARDO	Limu-bilbilo Wereda Agriculture& Rural development office
Masl	Meter above sea level
ME	Metabolizable energy
MJ	Mega Joule
Ml	Milliliter
Mm	Millimeter
MOA	Ministry of Agriculture
MOARD	Ministry Of Agriculture and Rural Development
MSc	Master of Science
N	No. of respondent
NDF	Neutral Detergent Fiber
NDS	Neutral detergent Solution
OBPED	Oromia beauru of planning and economic development
OMD	Organic matter digestibility
P	Phosphorous
RDA	Relatively drained area
SDW	Sub sample dry weight
SE	Standard error
SFW	Sub sample fresh weight
SPSS	Statistical package for social science
SWLA	Seasonally water logged area
TDM	Total dry matter
TDW	Total dry weight
TFW	Total fresh weight of individual Species
TLU	Tropical Livestock Units
WSC	Water-Soluble Carbohydrate

ABSTRACT

This study was conducted in Lemu-Bilbilo Wereda, Arsi Zone of Oromia Regional State on members of the dairy products processing cooperatives with the objective of characterizing the feeding systems, and feed resources in terms of quantity and quality in the study area. One hundred fifty one households owning dairy cattle and supplying milk to the cooperatives during the study period were selected purposely. A structured questionnaire format was prepared and an interview of each household was carried out to collect data on household structure and farming system characteristics, feeding systems, available feed resources and their nutritional qualities, dairy cattle feeding practices and performance of dairy cattle. Feed samples were collected from natural pastures, crop aftermath, crop residues, concentrates and tree legumes to estimate total DM yield and nutrient composition of the feedstuffs. Standard methodologies were followed to collect the feed samples and analyses their chemical composition. Descriptive statistics was used to analyze the data using SPSS. The results of this study showed that the average livestock herd size per household in terms of TLU was 20.44 (SE=0.87), cattle (16.12 TLU, SE=0.72) that represented 78.86% of the total herd size. About 39.20% of the cattle herd sizes were composed of crossbred while 60.80% were indigenous. Cows represent 51.05% of the total cattle herd followed by oxen that represent 28.47%. The objective of cattle keeping in majority of the farms was for milk, draught, income and meat purpose. Crop-livestock mixed farming was the commonly used farming system. Cereals, pulses, and oil seeds are the major crops grown in the study area. Grazing combined with stall feeding is the commonly used farming system. The major feed resources were natural pasture, crop residues, concentrates (wheat bran and linseed cake) and hay. Grasses are the major to cover the species composition of the natural pasture in both water logged and relatively drained pasture areas (57 and 83%, respectively) followed by sedges (37 and 10%, respectively). Barley and wheat straws are the major crop residues (53.81 and 27.94%, respectively). Majority of the feed available in the study area was originated from the natural pasture (56.39%) followed by crop residues (29.24%) and concentrates (5.06%). The total amount of DM estimated per household in the study area was 1.34 tons per TLU and this satisfied only 58.77% of the maintenance requirement. The nutrient content of *natural pasture in this study was 31.85 and 32.65% DM, 9.28 and 8.65% CP, 10.51 and 10.46 MJ/kg DM of ME, 0.29 and 0.33% Ca, and 0.19 and 0.23% P for water logged and relatively drained areas, respectively. Crop residues had DM, CP, ME, Ca, and P contents of 91.06-95.25%, 4.10-7.24%, 9.66-10.57 MJ/kg DM, 0.15-0.49% and 0.07-0.13%, respectively. The nutrient contents of linseed cake and wheat bran was 93.17 and 94.17% DM, 31.96 and 17.0.2% CP, 12.17 and 14.67 MJ/kg DM of ME, 0.34 and 0.09% Ca and 0.97% P each, respectively. Hay had DM content of 92.47%, CP content of 6.67%, ME content of 9.43MJ/kg DM, Ca content of 0.36% and P content of 0.22%. The mean total land holding was 6.67ha (SE=0.28) per household. The average size of tenured land was (5.46 ha) while the rest (1.21 ha) was contracted land. On average each household supplied a total of 108.62 MJ/kg DM, 1150.65 (g) of CP, 28.69 (g) of Ca and 38.88 (g) of P for a lactating cow. Much of ME (48.59%) and Ca (42.72%) originated from crop residues followed by Concentrates ME (37.16%) and Ca (16.66%) but much of P originated from concentrates (76.90%). The average peak daily milk yield for crossbred cows was 6.83 liters and for indigenous was 2.82 liters. The lactation length was 10.3 and 7.49 months for crossbred and indigenous cows, respectively. Age at first calving was 36.02 and 46.77 months and the calving interval were 19.90 and 23.53 months for crossbred and indigenous cows, and service per conception of 2.19 and 1.6 times were found for crossbred and indigenous cows, respectively. Conclusions were made on the feed resources and their nutrient composition in the study areas and appropriate recommendations were forwarded.*

Keywords: *chemical composition, dairy, Ethiopia, feed resources, feeding systems, nutrient content.*

1. INTRODUCTION

Ethiopia has the largest livestock inventories in Africa, including about 44 million cattle, 46 million small ruminants, 2.2 million camels, 6 million equine and 43 million chickens (Mitiku, 2004). The livestock sector plays a significant role in the national economy contributing about 15% of total GDP and 40% of agricultural GDP (Assefa, 1990; Winrock, 1992). Livestock exports accounted for 27% of merchandise exports and 34% of the total value of agricultural exports in 1992. Despite the large population, animal productivity in Ethiopia is low and even below the average for most countries in eastern and sub-Saharan Africa (Freeman *et al.,* 1998*).*

The country has large potential for dairy development (Azage *et al*., 2002), but the performance of the dairy industry in Ethiopia has not been encouraging when evaluated against even the dairy performance of east African countries, which have more or less similar agro-ecology (Alemu *et al*., 1998). This low productivity according to Azage *et al*. (1995) is due to a number of factors, which hindered the development of the livestock sub sector in the country. These include poor genetic potential of indigenous animals, inadequate veterinary services, shortage of animal feeds as well as the absence of good management and proper policy support for livestock development.

The Ethiopian highlands account for 40% of the country's land mass and almost half of the total tropical African highlands. In addition, about 70% of the human population in the country also inhabits the highlands. The area has temperate climate, relatively low disease pressure, favorable rainfall distribution, and 22-23 million hectares of grazing land (FAO, 1986). Livestock in the highlands are part of mixed farming complex. They provide inputs (draught power, transport, manure) to the other part of the farming system and generate consumable or saleable outputs (milk, manure, meat, hides and skin, wool, hair and eggs) (Alemayehu, 1985). Livestock production in Ethiopia is mainly based on grazing and/or browsing. In the highlands, crop residues and agro-industrial by-products augment natural pasture. In the pastoral system, livestock production is almost totally dependent on native pasture and woody plants (Daniel and Tesfaye, 1996; Zinash *et al*., 1998).

The natural grazing lands in the highlands of Ethiopia are seriously overloaded with stocks generally beyond their optimum carrying capacity causing overgrazing, erosion and overall land degradation (Zinash *et al*., 1996). Moreover, there is an ever-increasing human population pressure resulting in the shrinkage of grazing lands and feed shortage due to increased land use for cereal crop production. This has further deteriorated the carrying capacity of these grazing lands and has put up a question mark on health and productivity of livestock (Getachew *et al*., 1993). The quality of native pasture is also low due to their low content of energy and protein and high amount of fiber. This low quality is much worse for crop residues owing to their low content of essential nutrients (proteins, energy, minerals and vitamins) and low digestibility and intake (Zinash and Seyoum, 1991). In these areas except for selected classes of livestock, especially draught oxen and lactating cows, supplement to grazing is not provided for indigenous animals (Gashaw, 1992). Long periods of nutritional stresses are, thus, the scenarios in the Ethiopian highlands and effort made so far to cope with the problem using standard methodologies in the study area is inadequate and the productivity of dairy is seriously constrained by shortage of feed both in quantity and quality. Hence seeking better and applicable management strategies would be a rational approach and may help in improving dairy production and sustainable use of feed resources.

The Arsi Zone of the Oromia Regional State is located in the highlands of Ethiopia and one of the areas in Ethiopia, where high concentrations of dairy producers are found organized in cooperatives. Despite this fact little has been done to characterize dairy cattle production in general and the feed resources and feeding system in particular in the area. Thus, there is a need to investigate the feeding system and feed resources, feed quantity and quality as well as associated constraints, which is necessary to develop intervention mechanisms.

Thus the objectives of this study were:

- To assess the available feed resources and feeding systems of dairy farms in the study area;
- To determine the quantity and quality of the dairy cattle feed resources in the study area.

2. LITERATURE REVIEW

Feed represents the biggest cost of producing milk ranging form 50 % to 58.8 % of the cost of milk production (Coffey *et al*., 1982). Although feeding of dairy cows should be according to their production, feed intake is affected by various factors, among which is feeding practice (Sniffenen *et al.,* 1993). The livestock feeding systems in Ethiopia include grazing and browsing; cut and carry and stall feeding based on hay, crop residues and concentrates to some extent. At present, livestock in many places are fed almost entirely on natural pastures and crop residues. Grazing is done mainly on permanent grazing areas, fallow lands and crop aftermath. Forage availability and quality are not favorable year round and hence gains made in the wet season are totally or partially lost in the dry season. At present around dairy and fattening areas, there is insignificant production of improved pastures and forages. The contribution of agro-industrial by-products is also minimal and restricted to some urban and peri-urban farms (Alemayehu, 2004).

Mohamed and Abate (1995) indicated three feeding periods in the central highlands of Ethiopia: the main rainy season (June-September), when green feed is available; the dry season (October-February), when straw and other crop residues become gradually available and the short rainy season, when feed supplies decline, although new re-growth may occur depending on the time-lines and amount of the short rains.

2.2. Feed resources and their nutritive values

The lowland parts of Ethiopia, which account for approximately 60% of the total land in the country, are utilized for raising livestock (Taylor, 1984). Nevertheless, 70% of the livestock population lives in the remaining 40 % landmass of the country, which is generally classified as highland (Gryseels and Anderson, 1983). These highlands occupying the central part of Ethiopia possess a high potential for dairy development and are the largest of their kind in the sub-Saharan Africa (Abate *et al*., 1989).

Livestock feed resources in Ethiopia are mainly natural pasture, crop residues, improved pastures, forage crops and agro-industrialby products (Alemayehu, 2004). Yoseph (1999) in his study of feed resources of dairy cows in urban and peri-urban dairy production systems of Addis Ababa milk shed, categorized dairy cattle feed resources into five classes: pasture roadside grazing, hay, crop residues, concentrates and non-conventional feeds. In the highland crop livestock production system, livestock get their feed mainly from natural pasture and crop residues (Zinash and Seyoum, 1991; Gashaw, 1992: Gryseels and Anderson, 1983; Getnet, 1999).

2.2.1. Natural pasture

The grassland region of Ethiopia accounts for some 30.5% of the area of the country and is most extensive in the western, southern and southwestern semi arid lowlands. Even though, it is changing due to increasing population and cropping, the total grazing and browsing land in the country is estimated to be 61-65 million hectares (Alemayehu, 1998). The land covered by native pasture in the highlands is estimated to be about 7.3 million hectares (Lulseged, 1987). In more humid areas, open grasslands (90% of which covered by grass) with some trees are common. In the drier patches, bushes are common and the proportion of grasses is reduced to about 70% (Alemayehu, 2004).

In the highlands, natural grassland are confined to degraded shallow upland soils, fallowed cropland and to soils which cannot be successfully cropped because of physical constraints such as flooding and water logging (Getnet, 1999). Estimates of productivity of natural pasture vary probably due to variations in ecology, rainfall, soil type and cropping intensity. The previous estimates of natural pasture yield for highlands and mid altitude on freely drained soil was 3 tons of DM per hectare and on seasonally water logged fertile areas about 4-6 tons of DM per hectare (Alemayehu, 1998).

Species composition of natural pasture

The botanical composition of natural grasslands varies depending on topography, climate and soil type. In the highland areas, grasses constitute the main part of natural pastures and the composition of legume species increases with increasing altitude. In areas, which have 2,200 meters of altitude, there is a wide range of annual and perennial trifolium species and annual medicago species (Alemayehu, 1985). Moreover, the yield and quality of natural pasture in the Ethiopian highlands may be decreasing through years due to overgrazing, drought and lack of proper utilization (Zinash and Seyoum, 1991). Proper grazing management, improving pasture condition through fertilization, planting of quality forages, making of high quality hay are some of the major forage resource management practices required (Ensminger *et al*., 1990).

Botanical composition of natural pasture

The dry matter composition of pasture is very variable. Most pasture grasses generally have a dry matter content of 17 to 30 % (Gashaw, 1992) while pasture legumes have a DM content of 20-30% (Ensminger *et al*., 1990). The CP content ranges from 30 g/kg of DM in very mature herbage to over 300 g/kg of DM in young heavily fertilized grasses (McDonald *et al*., 1982). In Ethiopia, the CP content of pastures decline rapidly following the rapid growth during the rainy season (Kabaija and Little, 1988). The mean chemical composition of 148 samples of native grass hay collected during 1990 and 1991 from Selale area had CP content of 6.7% (Gashaw, 1992), almost the same as the mean CP content reported by Lulseged and Jamal (1989) (6.6%) for the Ethiopian highlands. These values are lower than the minimum requirement for optimum rumen function (7.5%) (Vansoest, 1982). The CF content is inversely related to CP content ranging from 200 g/kg of DM in young pasture to as much as 400 g/kg of DM in very mature samples. The total soluble carbohydrate of grasses varies from 40 g/kg of DM in some cocks foot varieties to over 300 g/kg of DM in certain varieties of rye grass. The cellulose and hemicelluloses content generally increase with increase of maturity ranging from 200 to 300 g/kg of DM and 100 to 300 g/kg of DM, respectively. Their lipid content as determined in the ether extract fraction (EEF) is comparatively low and rarely exceeds 40g/kg of DM (McDonald *et al*., 1982).

Effect of different factors on natural pasture

Both yield and quality of forage plants are affected by environmental factors like moisture, temperature, light intensity, soil, grazing intensity and species of grazing animals (Vansoest, 1982) and by stage of growth (McDonald *et al*., 1988). High temperatures have negative effects on crude protein (CP), ash, and water soluble carbohydrates (WSC) composition, but positive effect on crude fiber (CF) content of pasture species. However, high light intensity increases dry matter (DM) yield and WSC content of pastures, while it has a negative effect on CP, CF, lignin and ash contents (Vansoest, 1982). Rainfall distribution is another factor affecting the vegetation form and productivity of pastures. Water stress tends to increase digestibility and decrease DM yield due to retarded development and maturation of plants. The contents of cell wall and lignin have frequently been reported to be lower in water stressed herbage. The amount and distribution of rainfall also affects the CP and mineral contents of pastures. For example, calcium accumulates during drought period but phosphorous becomes high during rainfall. Similarly, nutrient contents of the soil influence the nutritive value of the natural pasture (Little, 1982). The application of Nitrogen fertilizer and inherent Nitrogen in Soil improves CP content and rate of photosynthesis (McDonald *et al.*, 1995).

Grazing intensity of natural pasture by animals has an impact on species composition of pasture and soil compaction (Stoddart *et al*., 1975). Hence, with increased grazing pressure, pasturelands will be dominated by unpalatable species (weeds) and legume components gradually disappear (Solomon, 2004). Moderate grazing on grass vegetation and quick replacement of removed shoots promote compensatory photosynthesis, which result in increased production of green biomass (Ranjhan, 1993).

Stage of growth is another important factor influencing the composition and nutritive value of tropical grasses and legumes (Faye, 1981; Kidane, 1993). As plant grows, there is a great need for fibrous tissues and, therefore, the main structural carbohydrates (cellulose and hemicelluloses) and lignin increase (McDonald *et al*., 1988). In the central highland of Ethiopia, a significant decrease in CP content and IVDMD of natural pasture from 9.6 % to 5.8 %, and from 65.9 to 61.2%, respectively, were observed (Kidane, 1993). On the other hand, as age of the natural pasture advanced, neutral detergent fiber (NDF) content increased from 61.8% to 66%. Similarly, Shenkute (1972) reported a significant increase in acid detergent fiber (ADF) and NDF as the grass matured from 30 to 80 Days.

2.2.2. Crop residues

In the highlands and midlands, various food crop residues including cereals crop residues (teff, barely, wheat, maize, sorghum and millet); pulse crop residues (faba beans, chicken peas, haricot beans, field peas and lentils), oil crop residues and rejected vegetables are providing a considerable quantity of dry season feed supply in many farming systems of the country. The availability of crop residues is closely related to the farming system, the type of crops produced and intensity of cultivation (Alemayehu, 2004). Teff and wheat straws are important sources of livestock feed in the highland vertisol area, while barley and oats straws are also important in areas where they are produced (Getachew *et al*, 1993). Currently, with the rapid increase of human population, expansion of arable land and with steady decrease in grazing land, the use of crop residues is increasing providing on average 10 to 15% of the total feed intake (MOA, 1998; Alemayehu, 1998; Alemu *et al* .1989; Getnet, 1999). It has also been suggested that in some localities under special crop-live stock production systems, the intake could increase up to 50% (MOA, 1998; Alemayehu, 1998). The use of farm produced by-products (stover, straws, bean and ground nut hulls) and of agro-industrial by-products as animal feed is an efficient and ecologically sound use of feed resource (Dzowela, 1990).

Crop residues vary considerably in yield, feeding value and digestibility. Among the cereals, wheat and barley have high straw yield, but are of inferior quality (Reed *et al*., 1986). The feeding value of crop residues is limited by their low voluntary intake, digestibility and nutrient content (Alemu *et al*., 1989; Chenost and Sansoucy, 1989). With the exception of fresh stover of maize and sorghum, the majority of crop residues have dry matter content of 90-93%. Generally, the crude protein content of crop residues range from 2.4-7% and the value of in-vitro dry matter digestibility (IVDMD) for straw is between 34 and 52% (Gashaw 1992, Abule, 1994). However, the nutritional values of crop residues vary according to the type of crop used. For example, cereal straws have 4.5% crude protein (CP), 79.4% neutral detergent fiber (NDF) and 51.1% IVDMD, in contrast to pulse straws, which have 7% CP, 62.9% NDF and 63.5% IVDMD. Furthermore, straws from oil crops have 5.4% CP and 66.4% NDF (Alemu *et al*., 1989).

The species of the plant, the agronomic practice used, soil, temperature, and the stage of growth influence the chemical composition, and palatability of straws. Daniel (1988), Tesfaye (1999) and Solomon (2004) reported that there is a considerable variation in the contents of CP and CF. However, the quality varies significantly from crop to crop. Residues from leguminous crops have better quality than the residues from cereals. Legume straws contain less fiber, high digestible protein than cereal straws (Daniel, 1988; Brananng and Person, 1990; Tesfaye, 1999; Solomon, 2004).

2.2.3. Fodder trees

Fodder trees and shrubs are important animal feeds in Ethiopia especially in arid, semi arid and mountain zones, where large number of the country's livestock is found (Alemayehu, 2004). Most browse species have the advantage of maintaining their greenness and nutritive value throughout the dry season when grasses dry up and deteriorate in quality and quantity (Rangnekar, 1992).

Tree fodders are generally rich in protein, vitamins and mineral elements and can be used as dry season feed sources and supplements to poor quality grasses and crop residues. However, their utilization is reduced by the presence of tannins and other phenolic compounds in their leaves (Devendra, 1990). Compared to grasses, fodder trees and shrubs have relatively high concentrations of crude protein and minerals. These nutrients are subject to less variation than in grasses and this particularly enhances their value as dry season feeds for livestock (Wilson, 1977; Ibrahim, 1981; Moog, 1989). However, nutritive value of fodder trees decreases with aging, since they become woody as they mature. But such situation can easily be overcome by regular lopping of the plants.

2.2.4. Improved (cultivated) pasture and forage crops

Improved (cultivated) forages yield is higher than the naturally occurring swards and have higher nutritional value. In addition, the length of the productive season is longer for cultivated pastures than for the native pastures, which provide an opportunity for dairy and fattening production to develop and use pasture and forage at a large scale. Over the past two decades, several forages have been tested under varying ecological zones for their adaptability. As a result, a number of useful forages have been selected for different zones. Improved pasture and forages have, therefore, been grown and used in government ranches, state farms, farmers' demonstration plots and dairy and fattening areas (Alemayehu, 1985; Alemayehu, 2004).

Forage crops and grasses grown to feed dairy cattle include oats, vetch, fodder beet, elephant grass, siratro, desmodium, rhodes, phalaris, sesbania, leucaenia and tree lucerne. Yield of improved pasture and forage ranges from 6 to 8 tons and 3 to 5 tons of DM per hectare, respectively, while that of tree legumes ranges from 10 to 12 tons of DM per hectare. In suitable areas, yield of oat-vetch mixtures are commonly 8 to 12 tons of DM per hectare. Despite the advantages of improved pasture and forage crops, due to land scarcity and crop-dominated farming, there has been limited spontaneous introduction of improved pasture and forages (Alemayehu, 2002).

In Ethiopia, most improved tropical species can be grown in the lowlands (1,500-2000 meters) except temperate species, which can grow in areas between 2,100 to 3,000 meters above sea level (Alemayehu, 2002). Pasture establishment is relatively difficult in the highlands compared to the humid, warmer and lower areas because of the types of soil and climate. In the wet season water logging, relatively low soil temperatures and reduced long and short radiation limits the establishment and subsequent growth of the pasture in the highlands (IAR, 1983). According to IAR, heavy emphasis is put in Ethiopia on the use of forage legumes in cropping system, through under-sowing, improvement of fallows, and establishment of tree legumes as hedges to partly address the major problems of long-term sustainability of crop production (Alemayehu, 2002).

2.2.5. Agro-industrial by-products

Agro-industrial by-products in the humid tropics are abundant and represent a substantial resource for increasing animal production. The use of these by-products for supplementary livestock feeding is justified when the forage supply is inadequate for the animals’ needs, in terms of either quantity or quality or when the cost of the supplementation is less than the value of increased animal production achieved. Supplementary feeding is also justified in times of drought or other feed shortages when the importance of providing the animal's immediate nutrient requirements to keep them alive some times outweighs other considerations, including the cost of the feed (ILCA, 1979).

Agro-industrial by products produced in Ethiopia includes by-products from flour milling, oil pressing, sugar factory, and breweries. These by-products are mainly used for dairy and fattening (Alemayehu, 1998). They are in general rich in energy or protein or both and have low fiber content and high digestibility compared with the other classes of feeds (Seyoum and Zinash, 1989). They also have more than 35% CP and 50-70% in-vitro dry matter digestibility (IVDMD) for oil seed cakes and 18-20% CP and more than 80 % IVDMD for milling by-products. Supplementing ruminants reared on low quality feeds with agro-industrial by-products enables them perform well due to its high nutrient density to correct the nutrient deficiencies set by the basal diet. Nevertheless, in contrary to its usefulness some agro-industrial by-products have side effects through the production of toxins, if kept under unsuitable storing condition. Aflatoxin in groundnut meal and gossypol in cottonseed meal are among the major toxic components (Alemu *et al*., 1989).

Linseed cake has a protein content of approximately 35 %, and is severely deficient in lysine. For this reason, it is more suitable for ruminants and horses than for swine and poultry (Cheeke, 1991). Linseed meal is unique among the oilseed residues in that it contains from 30 to 100 g/kg of mucilage which is almost completely indigestible by non-ruminants, but can be degraded by the microbial population in the rumen. It is readily dispersible in water, forming a viscous slime. Immature linseed contains a small amount of a cyanogenetic glycoside, linamarin, and an associated enzyme linase, which is capable of hydrolyzing it with the evolution of hydrogen cyanide which is extremely toxic. Death of animals consuming the product results from combination of the cyanide with cytochrome oxidase, leading to an immediate cessation of cellular respiration and anoxia. Low-temperature removal of oil may produce a meal in which unchanged linamarin and linase persist; such meals were proven toxic when given as gruel since cyanide production begins as soon as the water is added. Normal processing conditions destroy linase and most of the linamarin and the resultant meals are quite safe. In ruminant animals the hydrogen cyanide formed by linase action is absorbed into the blood very slowly and this, coupled with its rapid detoxification in the liver and excretion via the kidney and lungs, ensures that it never reaches toxic levels in the blood. The protein of linseed meal is of poorer quality than those of soybean or cottonseed meals due to lower methionine and lysine contents. Linseed meal has only moderate calcium content, but is rich in phosphorus, part of which is present as phytate. It is useful source of thiamin, riboflavin, nicotinamide, panthothenic acid and choline (McDonald, *et al*, 2002).

By-products from the flour milling industry such as wheat bran are potential nutrient sources for livestock. The bran is the outermost layer of the seed, which is high in fiber, but also contains some flour and is relatively higher in CP (17%) content than the seed. Wheat bran is palatable and has a laxative property due to its fiber and non-starch carbohydrate content. When compared to the whole seed, wheat bran has a better amino acid balance and is high in phosphorus content and low in calcium. Generally, the fiber content of wheat bran makes it a preferred supplement to ruminants rather than monogastric animals (Cheeke, 1991).

2.3. Feeding practices

A study by Samuel (2005) in Ada-Liben Wereda indicated that more farmers give priority for oxen, cows and calves in decreasing orders in their feeding of available feed resources. The amount and type of feeds allocated to different classes and species of animals is mainly based on seasonal availability than level of livestock productivity. Some crop residues were stored to supply for working oxen when cultivation is practiced mainly from February to March and June to August. Yitaye *et al*., (2000) on the other hand have reported that cows receive a relatively more amount of maize and noug cake supplementation followed by work oxen and calves.

According to the assessment made by Gashaw (1992) in the Selale Dairy Development Project areas in Ethiopia, the amount of feed supplied to different classes of livestock was 2,466 kg of feed for crossbred dairy cow; 1,562 kg for other crossbred cattle and 3,113 kg for other livestock. According to the same author, about 35 % of the total on farm DM was consumed by crossbred dairy cows although they accounted only 17% from the total tropical livestock unit (TLU) in the farms.

3. MATERIALS AND METHODS

3.1. The study area

3.1.1. Location

This study was carried out in the highland of Arsi Zone at Lemu-Bilbilo Wereda around Bekoji which is found at about 231 kms south eastern of Addis Ababa. Arsi Zone is one of 14 zones of Oromia National Regional State with an area of 23,674.7 km^2 sub-divided into 24 weredas. It is located at 6^0 59’-8^0 49’N latitude and 38^0 41’- 40^0 44’E longitudes. It shares boundaries with East Shewa, West Hararge and Bale Zones of Oromia; Afar and Southern Nations Nationalities and Peoples National Regional States (Adisu, 2008).

The study area is located in the high potential cereal-livestock belt of Ethiopian highlands. The altitudinal ranges from 1500 to 4460 meters above sea level where the dairy cooperatives are located on high land areas (on the same agro ecology) (LBWARDO, 2007) (Figure 1).

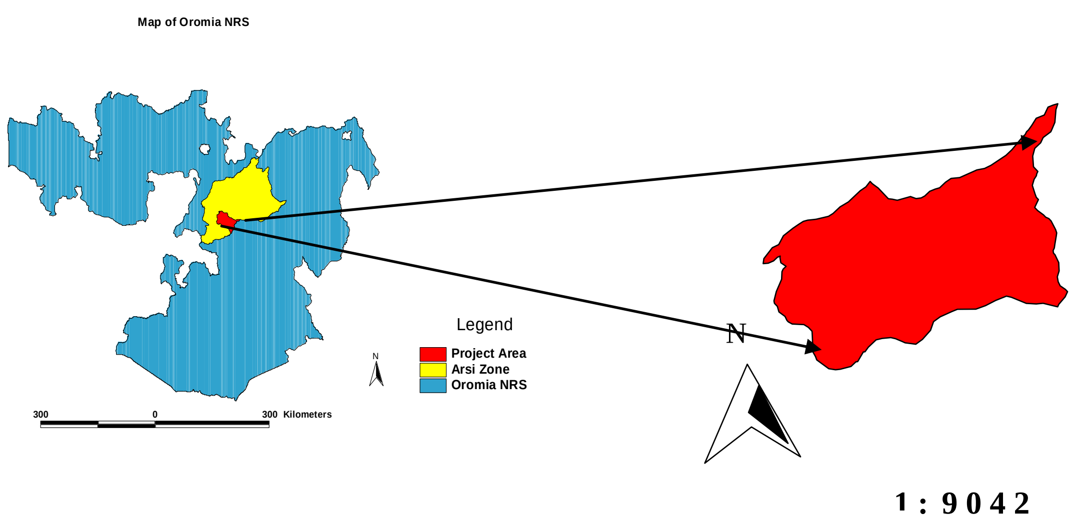

Figure 1. Location of the study area (Lemu Bilbilo Wereda)

3.1.2. Climate, soil type and vegetation

The rainfall of the area is bimodal with short rainy season and the long (main) rainy season occurring in spring and summer, respectively. The maximum rainfall occurs in August (KARC, 2001). The study area receives mean annual rainfall of 1100 mm with the minimum and maximum being 800 and 1400 mm, respectively. The mean, minimum and maximum temperature is 13, 6 and 21^{0}C, respectively (KARC, 2001).

The soil types of the Wereda are clay vertisol, vertisol and nitisol (LBWARDO, 2005). The natural vegetation type commonly observed in the study area are highland trees, which included afro-montane forests and trees on agricultural lands and afro-alpine mountain vegetation (Ahmed, 2002), forage grasses like fodder beet and oat in the higher altitudes (4460 masl), elephant grass and alfalfa in the middle altitudes (2980 masl) and vetch, lablab and cowpea in the low altitude (1500 masl) (LBWARDO 2006).

3.1.3. Population, farming systems and livestock population

The Study Wereda has a total landmass of 100,600 ha, which is divided into 25 peasant associations, and has 197, 700 people (49% male and 51% female) out of which 88.54% live in rural areas and 11.46% live in urban settings. Of the total land mass, 69,649 ha is agricultural cropland 1,118 ha is irrigable land, 2,973 ha is forest land and 6,746 ha is pastureland. The area encompasses traditional park land, agro-forestry system and monoculture cropping system. The major crops grown in the area are barley, wheat, linseed, teff, field pea, faba bean, rapeseed and lentil mainly with one harvest per year and have popular fertilizer utilization which is Di ammonium Phosphate.

The livestock population in the study area includes 286,518 cattle, 64,347 goats, 301,917 sheep, 66,373 horses, 52,743 donkeys, 4232 mules, 70744 poultry and 16991 bee colonies(OBPED, 2001).

3.2. Study population

Smallholder farmers owning dairy cattle in Lemu-Bilbilo Wereda, who are members of the Dairy Products Processing Cooperatives, represent the study population.

3.3. Study design

Descriptive cross-sectional study was carried out to assess the constraints, the feeding systems and on farm available feed resources for dairy cattle in terms of type, quantity and quality after the main rainy season (from October, 2007 to January, 2008).

3.4. Sampling techniques

There are five Dairy Products Processing Cooperatives in the Wereda namely Lemu Aria, Lemu Michael, Lemu Dima, Bekoji and Meraro. Considering the fact that there is high concentration of dairy producers in the cooperatives, all the members of the five cooperatives that were supplying milk to the cooperatives during the study period were considered in the study. Thus, a total of 151 family heads (households) were included in the questionnaire survey study purposely. From those, 15 households owning grazing land were selected randomly and samples of natural pasture were collected.

3.5. Data Collection

3.5.1. Questionnaire survey

Structured questionnaire format was prepared and an interview of sampled households was carried out to collect data on demographic and farming system characteristics of farm households, livestock and dairy cattle herd size and composition, objective of cattle keeping, dairy cattle management practice (housing, breeding and health care practices) constraints of the dairy cattle production in the study area, feeding systems, available feed resources in terms of type, quantity, seasonal variability of feed resources and feeding practices were assessed (Annex 1).

3.5.2. Collection of feed samples

Natural pasture

Feed samples were collected from different sites of 15 individual farmers (three household enclosures or pasturelands from each cooperative) who are members of the Dairy Products Processing Cooperatives to determine the pasture yield, species composition and quality. The enclosures of pasturelands were classified as relatively drained and seasonally water logged areas and six, 1 meter by 1 meter quadrants were randomly set in each selected pastureland (Coaldrake *et al*, 1976; L'timannetje, 1978). This made a total of 90 samples in the study area.

Pasture components in each quadrant were cut at the ground level. After cutting the samples were weighed immediately using electronic sensitive balance and transferred into plastic bags, fastened at the top. Samples were kept in a cool area until sampling for the day was completed. Then the sample from each quadrant were mixed thoroughly and sub sample of 500 gm were reserved for DM determination after being dried (60^0c for 72 hrs) so as to know the yield, and then used for determination of nutrient composition, while the remaining pasture samples from each quadrant were used to know botanical composition, during which each grass type was sorted out by hand, weighed on fresh basis and dried in an oven at Kulumsa Agricultural Research Center to know the botanical composition of each species in DM basis. From each pasture sample, representative sample of each species with flowering head was labeled, pressed and taken to the National Herbarium of Addis Ababa University for species identification.

Crop residues

Among the different crop residues produced in the study area four of the abundantly used types (barley, wheat, faba bean and field pea straws) were collected from four households of each cooperative, which makes a total of 80 samples of crop residues (20 from each type of the crop residues). After thorough mixing (making a composite sample of each item of crop residues), only 20 sub samples of crop residues (five from each crop residue) were taken for laboratory analysis in Holeta Agricultural Research Center.

Tree legumes

Four households who have already planted tree legumes, and used the tree (tagasaste) as livestock feed were purposely selected for sampling the feedstuff and the tree legumes were cut at a height of 1 meter above ground, and a total weight of edible and none edible parts were recorded separately. After weighing the edible parts (leaf, pods and pencil size stems), each samples was sub sampled (weighing 500 g fresh weight) dried in forced oven, weighed and used to know the DM and then taken for laboratory analysis in Holeta Agricultural Research Center.

Concentrates

Supplemental feed samples (wheat bran and linseed cake), which were widely used in the study area were collected from seven households and source distributors. Thus, five samples of linseed cake and two samples of wheat bran were collected and then taken for laboratory analysis in Holeta Agricultural Research Center.

3.6. Botanical composition of natural pastures

The sub-sampled pasture samples (500 g) were sorted out into different species by hand weighed using electronic sensitive balance and put into paper bags that were properly labeled. There after, every labeled sample was taken to Kulmumsa Agricultural Research Center and dried in an oven at 60^0C for 72 hrs to determine DM. The resultant dried samples were weighed and botanical composition was determined using the dry weight rank (DWR) method of (Tothill *et al*., 1978). The following formula was used to calculate botanical composition:

$$\text{TDW of a species} = \frac{\text{TFW of a species}}{\text{SFW of a species}} \times \text{SDW of species} \quad \ldots \; (1)$$

$$\%\text{ proportion of a species} = \frac{\text{TDW of a species}}{\text{GTDW}} \times 100 \quad \ldots \; (2)$$

Where, TFW = Total fresh weight of individual Species,

SFW = Sub sample fresh weight,

TDW = Total dry weight,

SDW = Sub sample dry weight,

GTDW= grand total dry weight

3.7. Quantity estimation of available feed resource

3.7.1. Dry matter yield of natural pasture

The pasture yield was determined on DM basis by harvesting forage samples from the same quadrant area as described above. The average fresh weight per quadrant was recorded and sub samples were dried in an oven at 60^0C for 72 hrs. The average dry weight of the pasture samples per quadrant was calculated, which was then extrapolated into dry matter yield (DMY) per hectare.

The total amount of DM available in natural pastures in the study area was determined by multiplying the average value of grazing land holding with the per hectare DM output of the natural pastures (Annex 6).

3.7.2. Available crop residues, fallow land and after math grazing

The quantity of available crop residues in (DM basis) was estimated from the total crop yields of the households, which was obtained from questionnaire survey, using the conversion factors that are utilized by FAO (1987) for the Ethiopian condition (Annex 5). The factors used in the conversion were 1.5 for barley, wheat, teff, oats; 2 for maize and 1.2 for pulse and oil crop straws. The 90% utilization factor was considered (Adugna, 1990). And quantity of available DM in fallow land and aftermath grazing was determined by multiplying the available land by the conversion factors of FAO (1987) (1.8) for fallow land and (0.5) for grazing aftermath (Annex 4).

3.7.3. Quantity of tree legumes

The total available DM in tree legumes per household was estimated by multiplying the mean DM value obtained in this study by the number of trees available on each farm (Petmak, 1983).

3.7.4. Estimating available concentrates

The quantity of concentrates (supplements) like wheat bran and linseed cake available in the study area in each farm household was obtained by interviewing the farmers during the questionnaires survey.

3.8. Chemical composition of different feedstuffs

Among the collected total feed samples, 30, 20, 4 ,7 and 3 representative samples of natural pastures, crop residues, tree legumes, agro-industrial by-products and hay, respectively, were taken to ILRI for mill at a size of 1mm and then to the nutrition laboratory of Holeta Agricultural Research Center. The samples were processed in the laboratory to determine DM, Ash, CP, DOMD, NDF, ADF and minerals (Ca and P) contents.

- The DM content of natural pasture was determined after oven drying of the samples using the formula of dry matter determination as recommended by John (1992) (% DM= DW/FW x 100)
- DM, Ash and CP were determined by the standard methods of AOAC (1980) (Annex 2 No 1, 2).
- NDF and ADF were determined by the methods recommended by Goering and Vansoest (1970) (Annex 2 No 3).
- A two stage rumen fluid pepsin technique of Tilley and Terry (1963) was used to determine in-vitro organic matter digestibility (Annex 2 No 4) and then DOMD was calculated.
  i.e. % DOMD or OMD%DM= $\left(\frac{\text{OM sample-OM residue}}{\text{DM sample}}\right)$ x100 (EIAR, 2007)
- ME was estimated from DOMD using the formula ME (MJ/Kg DM) = 0.016 x DOMD as recommended by McDonald *et al*. (1995).

3.9. Estimation of requirement and Feed supply balance

The availability of total DM in the main rainy season from natural pasture, crop residues, crop aftermath, tree legumes and concentrates was compared to the annual DM requirements of the livestock population in the sampled households. Data of livestock population in the sampled households was obtained from the interviewed farm heads during the survey. For the case of comparison, the number of livestock population was converted into tropical livestock units (TLU) using the conversion factors of Varviko (1991) (Annex 3).

The DM requirements of the livestock population was calculated based on the daily DM requirements for maintenance of a 250 kg dual purpose tropical cattle, which is an equivalent of one TLU (Kearl, 1982)

3.10. Data management and statistical analysis

The Microsoft office excel (2003) spreadsheet was used to enter data and SPSS (release 12.01, 2003) was used to calculate descriptive statistics.

4. RESULTS

4.1. Demographic and farming system characteristics

4.1.1. Demographic characteristics of sampled households

As presented in Table1, the average age of the farm heads was 49.14 years. The average family size of the sampled households was 8.7 with the minimum and maximum of 2 and 50 persons, respectively. Most of the sampled households are headed by males (87.42 %) than females (12.58 %).The educational level of the sampled households was 31.13% basic education, 41.72 % elementary (1-6), 25.17 % secondary (7-12) and 1.99 % above 12th grade.

Table 1. Demographic characteristics of sampled households

Variables	N	Mean $\pm$ SE	Proportions
Age of the household head	151	49.14 $\pm$ 0.98	-
Family size of the household	151	8.70 $\pm$ 0.37	-
Sex of the household leader			-
Male	132	-	87.4
Female	19	-	12.6
Educational status			
Basic education	47	-	31.13
Grade 1-6	63	-	41.72
Grade 7-12	38	-	25.17
Above 12th grade	3	-	1.99

N=number of respondents, SE=standard error

4.1.2. Farming system characteristics

Livestock herd size and composition

The average livestock herd size per household in this study was 20.44 TLU, cattle being 16.12 TLU (78.86 %) of the total livestock herd size. The representation of goats in the sampled households was insignificant (0.05 TLU) (Table2).

Table 2. Livestock herd size and composition per household (TLU), N=151

Variables	Mean $\pm$ SE
Livestock	20.44 ± 0.87
Cattle	16.12 ± 0.72
Sheep	1.21 ± 0.11
Goat	0.05 ± 0.01
Donkey	0.63 ± 0.05
Horse	2.31 ± 0.10
Mule	0.12 ± 0.03
Poultry (number)	4.17 ± 0.38

N=number of respondents/population

The sampled households indicated that there is a decreasing trend in livestock herd size in the past ten years with variations in the proportion of respondents regarding the situation for each species: 54.3% for cattle, 50.33% for sheep, 25.83% for goat, 25.83% for donkey, 46.36% for horse, 3.97% for mule and 35.10% for poultry.

Important (major) crops cultivated

Cereals are produced by all (100 %) of the respondents, while pulses and oil crops produced by 48.34% and 65.56% of the respondents, respectively. The annual yield of cereal crops, pulses and oil seeds on average was 1.67, 0.40 and 0.79 tons/ha, respectively. The major cereal crops grown in the study area were barley, wheat, teff and maize cultivated by 97.35%, 92.72%, 27.15% and 0.66% of the respondents, respectively. Faba bean and field pea were the most commonly grown pulses cultivated by 60.26% and 31.79% of the respondents, respectively. Linseed and rapeseed were cultivated by 43.05% and 51.66% of the respondents and represent the major oil crops in the area (Table 3).

Table 3. Major crops cultivated by the sampled households in the study areas

Variables	N	%
Cereals	151	100
Barley	147	97.35
Wheat	140	92.72
Teff	41	27.15
Maize	1	0.66
Pulses	73	48.34
Faba bean	91	60.26
Field pea	48	31.79
Oil crops	99	65.56
Rape seed	78	51.66
Linseed	65	43.05

N=number of respondents**,** %=percent

Land holding and use pattern

The average size of landholding per household and the use pattern are presented in Table 4. The total landholding per household in this study area was 6.67 ha. The total land owned by the households is the sum of tenured and contract lands (purchased from other farmers for a certain period of time), which constituted about 5.46 ha (81.86%) and 1.21 ha (18.14%), respectively. The average area of land used for cultivation and pasture being 3.03 and 3.37 ha, respectively. The remaining 0.27 ha was fallow land. From the pastureland, 1.79 ha (53.12%) was water logged and 1.58 ha (46.88%) was relatively drained. The proportion of land used for grazing/pasture is 50.52% of the total land holding. The largest proportion of cropland (79.2%) and pastureland (80.12%) were privately owned while the remaining land was contracted.

Table 4 .Mean and standard errors of land holding and use patterns in the sampled households N=151

Variables	Mean $\pm$ SE
Crop land (ha)	3.03 $\pm$ 0.14
Grazing/pasture land (ha)	3.37 $\pm$ 0.19
Water logged pasture land(ha)	1.79 $\pm$ 0.13
Drained pasture land(ha)	1.58 $\pm$ 0.14
Fallow land(ha)	0.27 $\pm$ 0.05
Total land holding/household(ha)	6.67 $\pm$ 0.28

N=number of populations

From the total land allocated for crop cultivation, 72.94% was used for cereals cropping, while 10.23% and 16.83% were used to cultivate pulses and oil crops respectively.

4.2. Dairy cattle production

4.2.1. Objectives of cattle keeping and major sources of income

All the sampled households keep cattle for multiple purposes including as sources of milk, draught power, income from sale and meat. Almost all of the farmers (99.34%) generate income from a mixed crop-livestock type of farming by producing crop, dairy products and livestock for sales. Very few respondents were generating income only from dairy and livestock products (0.66%).

4.2.2. Cattle herd size and composition

The average cattle herd size per households was 16.12 TLU, from which 6.32 TLU (39.20%) were cross breeds while 9.81 TLU (60.80%) were indigenous. Cows comprised 8.23 TLU (51.05%) of the total cattle herd followed by oxen 4.59 TLU (28.47%) from which 3.23 TLU (70.37%) were indigenous (Table 5).

Table 5. Cattle herd size (Mean ± SE) and composition in TLU.N=151

Variables	Indigenous	Cross breed	Total	
	Mean ± SE	Mean ± SE	Mean ± SE	%
Cattle	9.81 ± 0.42	6.32 ± 0.56	16.12 ± 0.72	
Cows	4.42 ± 0.24	3.81 ± 0.35	8.23 ± 0.46	
Heifers	0.64 ± 0.09	1.83 ± 0.07	3.23 ± 0.10	
Steers/oxen	3.23 ± 0.15	1.37 ± 0.17	4.59 ± 0.22	
Calves	0.69 ± 0.04	0.35 ± 0.04	1.04 ± 0.05	
Bulls	0.30 ± 0.07	0.14 ± 0.04	0.43 ± 0.08	

N=number of respondents, SE=Standard error

4.2.3. Cattle housing and major constraints

Cattle were housed separately in corrals or barns in 60.93% of the households. The remaining households (39.07%) house their cattle mixed with other livestock either in corrals or barns.

The major constraints of dairy cattle production besides feed shortage in perception of the respondents in the study area were lack of improved breed, disease outbreak, lack of water, lack of technical know how, mastitis problem, lack of AI service and shortage of labor and land in their order of importance.

The major cattle health problems of the study area as per the perception of the sampled households were black leg, rabis, endoparasites like fasiolasis , exoparasites like mange, foot and mouth disease (FMD) and anthrax in their order of importance.

The livestock development services provided by the Wereda Agricultural Development Office and private suppliers are vaccination, AI service, supply of improved breed and occasional supply of medicaments in their order of importance.

4.2.4. Performance of dairy cattle

The average milk yield of crossbred cows was in the range of 6.83 liters (SE=0.28) in early lactation to 1.81 liters (SE=0.07) at the end of lactation. The daily milk yield in indigenous cows ranged from 2.82 liters (SE=0.07) in early lactation to 0.87 liters (SE=0.03) at the end of lactation. Lactation length of 10.30 and 7.49 months, age at first calving of 36.02 and 46.77 months, calving interval of 19.90 and 23.53 months and service per conception of 2.19 and 1.6 times were found for crossbred and indigenous cows, respectively. In general the crossbred cows had higher milk yield and longer lactation length than the indigenous cows. The age at first calving and calving interval were shorter for crossbred cows while number of service per conception was smaller in indigenous cows.

4.3. Feeding systems and available feed resources

4.3.1. Feeding systems

The feeding system in almost all (98.01%) of the respondents was based on grazing combined with stall feeding; cattle spend most of the time in the day on pasturelands and are supplied with crop residues and/or other supplements as available during morning and evening. The remaining small proportions (1.99%) totally depend on grazing. The commonly used systems of grazing in the study area were free grazing (35.10%), herding (26.49%) and paddocking (38.40%) in the dry season and herding (54.3%) and paddocking (45.69%) in the wet season.

About 84.77% of the sampled household's cut grass within the time interval of July to November both to dry and store while others (9.27%) feed the cut pasture as green. The trend of pastureland in the last five years was decreasing in 70.86% of the respondents due to farming expansion (66.89%), sharing to family members (1.99%) and displacement for investment (1.99%). In 17.88% of the households there was no change while in 11.26% of the households land holding increased due to contract purchase.

In 70.20% of the respondents there was variation in grazing time for different groups of cattle: about 7.64 hrs for lactating animals, 8.68 hrs for traction oxen and 9.07 hrs for other animals.

4.3.2. Feed resources

The feed resources available on farm include natural pasture (99.34%), crop residues (96.03%), linseed cake (90.73%), hay (74.17%), wheat bran (66.23%), oat (13.25%), '*enset'* (2.65%), '*atela'* (1.99%) and barley flour and cake (1.32%).

The DM yield of the natural pasture in the seasonally water logged area was 3.65 tons/ha while that of the relatively drained area was 3.60 tons/ha. The study on species composition of natural pasture revealed that in the seasonally water logged area, grasses constituted 57% of the biomass containing twelve species, followed by sedges (37%) with two species, legumes (3%) and weeds or others (3%). Among the grass species the dominant one was *Pennisetum* sphocelatum (41.93%). In the sedge group, the highest proportion was that of *Cyprus rigidifolium* (30%).

In the relatively drained areas, grasses constituted about 83% of the botanical composition followed by sedges (10%), weeds or other species (4%) and legumes (3%). *Pennisetum sphocelatum* (28.64%) and *Andropogon abyssinicus* (23.11%) and *Cynodon dactylon* (13.45%) were the dominant grasses while *Cyprus rigidifolium* (9.71%) was the most frequently found sedge. *Trifolium tembense* was the predominant legume species found in both seasonally water-logged (3.21%) and relatively drained (2.85%) areas (Table 6).

The major crop residues available in the study area were barley straw that constituted 53.81% of residues followed by wheat straw (27.94%), linseed straw (6.35%), field pea straw (4.13%), faba bean straw (3.97%) and teff straw (3.81%) (Table7). A total of 6.3 tons of crop residues was produced per household annually in the study areas. The sampled households store their crop residues on average for about 8 month within the range of 5 to 12 months. These households store their residues either stacked in stall or stacked in open air. The agro-industrial by-products available in the study area were linseed cake and wheat bran. Only 11.26% of the respondents were growing tree legumes and forage grasses since six years back and only about 3.32% were utilizing the tree legumes, particularly tagasaste, to feed their animals. The leaf: stem ratio of tagasaste in this study was 14:29 and those were given only to lactating animals. The average number of tagasaste tree per household was 22.25. Each sampled household acquired on average a total of 0.66 tons of linseed cake and 0.60 tons of wheat bran.

Table 6. Species composition of natural pasture in the seasonally water logged and relatively drained areas

Scientific name	Local Name	%age composition	
		SWLA*	RDA**
Grasses			
Pennisetum sphocelatum	Migra	41.93	28.64
Pennisetum thunbergii	Migra	1.08	0.02
Andropogon abyssinicus	Balemi	4.33	23.11
Andropogon chrysostachyus	Balemi	0.03	0.37
Eragrostis botryodes	Arda	2.30	1.52
Sporobolus africanus	Muri	0.82	0.38
Eleusine floccifolia	Chekorsa	0.02	5.59
Digitaria abyssinica	Warete	1.64	9.17
Poa schimperiana	-	0.17	0.62
Desehampesia abysinsca	Ura	-	0.14
Cynodon dactylon	-	3.82	13.45
Hyparrhenia anthistirioides	-	0.28	0.013
Lolium sp	-	0.02	0.07
Legumes			
Trifolium tembense	Amakita	3.21	2.85
Trifolium simense	Amakita	0.22	0.02
Sedges			
Cyprus rigidifolium	Engicha	30.00	9.71
Cyprus plateilema	Engicha	7.22	-
Others	-		
Satureja paradoxa	Urgo	0.15	1.82
Uebelinia abyssinica	Abakaso	0.10	0.40
Rotala sp	Abakaso	1.25	1.54
Alchemilla, fischeri	Tuta	0.21	0.13
Rumex nepalensis	Shulti	0.06	0.36
Centella asiatica	Balee	1.05	0.09
Commelina diffusa	-	0.09	0.01

- = Not available,*SWLA=seasonally water logged area, **RDA=relatively drained area

Table 7. Quantity of available crop residues per household in DM basis

Types of crop residues	DM (ton)	%age
Barley straw	3.39	53.81
Wheat straw	1.76	27.94
Linseed straw	0.4	6.35
Field pea straw	0.26	4.13
Faba bean straw	0.25	3.97
Teff straw	0.24	3.80
Total	6.3	100

The amount of feed available per household on DM basis is presented in Table 8. The total amount of DM available per household in this study was 21.59 tons. Most of the DM in a household originated from natural pasture (58.82%) and crop residue (26.26%). Considering the average cattle herd size of 16.12 TLU, there would be on average a total of 1.34 tons of DM per TLU annually in each household. The minimum maintenance requirement for a TLU is 2.28 tons (2.5% of the body weight of an animal). These available feeds, therefore, satisfied only 58.77% of the maintenance requirement of DM per annum per TLU.

Table 8. Quantity of available feed resource per household in DM basis

Feed resources	DM (tons)
Pasture from seasonally water logged areas	6.94
Pasture from relatively drained areas	5.76
Crop residues	5.67
Fallow land	0.48
Crop aftermath grazing	1.52
Linseed cake	0.61
Wheat bran	0.57
Tagasaste	0.04
Total	21.59

The estimated total amount of DM available per year in the sampled households of the study area is shown in Table 9. A total of 2,908.47 tons of DM was available in sampled households. More than half of the total DM (56.39%) was contributed by natural pasture. Crop residues made about 29.24% of the total DM. The remaining proportion originated from crop aftermath (6.79%), fallow land (2.49%), linseed cake (3.00%), wheat bran (2.06%) and Tagasaste (0.02 %) (Table 9).

Table 9. The Estimate of total DM available per annum in the sampled households in the study area

Feed resources	TDM(tons)	% from TDM
Natural pastures	1640.09	56.39
Crop residues	850.5	29.24
Fallow land	72.48	2.49
Crop after math	197.6	6.79
Lin seed cake	87.12	3.00
Wheat bran	60	2.06
Tagasaste	0.68	0.02
Total	2908.47	100.00

TDM= Total dry matter

4.3.3. Nutritional quality of the available feed resources

The mean values of nutrient contents of different feedstuffs in the study area are presented in Table 10. The results of laboratory analyses of nutrient contents showed that the DM content of the natural pasture ranged from 28.32% to 35% (with the mean of 31.85%) in the seasonally water logged and 22.84% to 41.66% (with the mean of 32.65%) in the relatively drained areas. Linseed cake and wheat bran had mean DM content of 93.21% and 94.17%, respectively. The mean DM content of barley straw, wheat straw, faba bean straw, field pea straw, hay and tagasaste were 91.06%, 91.74%, 95.25%, 95.20%, 92.47% and 49.95%, respectively. The highest crude protein contents were found in linseed cake (31.96%), wheat bran (17.02%) and tagasaste (15.60%). The CP contents of natural pastures in seasonally water logged and relatively drained areas were 9.28% to 8.65%, respectively. Crop residues had CP content ranging from 4.10% in wheat straw to 7.24% in field pea. Hay had CP content comparable to that of faba bean but lower than natural pasture (Table 10).

The metabolizable energy content of natural pasture, barley straw, wheat straw and faba bean straw were comparable and in the range of 10.57 -10.3 MJ/kg DM. The highest value of ME was found in wheat bran (14.67 MJ/kg DM) followed by linseed cake (12.17 MJ/kg DM) and the lower values of ME content were found in tagasaste (7.34 MJ/kg), hay (9.43 MJ/kg) and field pea straw (9.66 MJ/kg DM).

The NDF and ADF contents of all available feed resources were in the range 23.21% to 74.53% and 11.00% to 51.7%, respectively (Table 10). Natural pasture, crop residues and hay had high values of ADF and NDF. The NDF content of tagasaste was also among the highest. The calcium contents of pulse residues (0.40-0.49%) and tagasaste (0.47%) were higher than the other feedstuffs. The lowest content of calcium was found in wheat bran (0.09%). Highest level of phosphorus was found in linseed cake and wheat bran (0.97%). Barley straw and wheat straw had the least content (0.07%) of phosphorus.

Table 10.Nutrient composition (Mean ± SE) of different feedstuffs in study areas

Feedstuffs	N	Mean ± SE						
		DM (%)	CP (%)	ME (MJ/kg)	NDF (%)	ADF (%)	Ca (%)	P (%)
Pasture (SWLA)	15	31.85 ± 0.51	9.28 ± 0.54	10.51 ± 0.19	66.53 ± 0.71	39.76 ± 0.49	0.29 ± 0.02	0.19 ± 0.01
Pasture (RDA)	15	32.65 ± 1.36	8.65 ± 0.49	10.46 ± 0.22	66.65 ± 0.51	40.54 ± 0.70	0.33 ± 0.03	0.23 ± 0.02
Barley straw	5	91.06 ± 0.26	5.73 ± 0.59	10.57 ± 0.18	73.66 ± 0.55	45.35 ± 1.17	0.23 ± 0.03	0.07 ± 0.01
Wheat straw	5	91.74 ± 0.28	4.10 ± 0.64	10.30 ± 0.08	74.53 ± 0.52	49.25 ± 1.10	0.15 ± 0.03	0.07 ± 0.01
Faba bean	5	95.25 ± 0.11	6.67 ± 0.20	10.35 ± 0.11	62.11 ± 0.08	51.09 ± 0.06	0.40 ± 0.01	0.13 ± 0.03
Field pea	5	95.20 ± 0.19	7.24 ± 0.62	9.66 ± 0.34	62.65 ± 0.27	51.73 ± 0.44	0.49 ± 0.03	0.13 ± 0.02
Linseed cake	5	93.21 ± 0.10	31.96 ± 0.10	12.17 ± 0.66	31.59 ± 0.81	20.57 ± 0.36	0.34 ± 0.00	0.97 ± 0.02
Wheat bran	2	94.17 ± 0.01	17.02 ± 0.24	14.67 ± 0.08	23.21 ± 0.24	11.00 ± 0.28	0.09 ± 0.00	0.97 ± 0.07
Hay	3	92.47 ± 0.25	6.67 ± 0.95	9.43 ± 0.58	67.47 ± 0.80	41.34 ± 1.74	0.36 ± 0.06	0.22 ± 0.06
Tagasaste	4	49.95 ± 0.01	15.60 ± 0.54	7.34 ± 0.50	61.71 ± 5.52	25.65 ± 1.84	0.47 ± 0.03	0.22 ± 0.01

N=number of observations, DM=dry matter, SE=standard error, CP= crude protein, ME= metabolizable energy, NDF=neutral detergent fiber, ADF= acid detergent fiber, Ca=calcium, P=phosphorous

4.4. Dairy cattle feeding practice

As presented in Table 11, the largest quantity of feed in DM basis was provided to lactating cows (9.8 kg), followed by oxen (5.96 kg) and pregnant cows (3.06 kg). Heifers, non-lactating cows and non-pregnant cows also received a significant share of the total DM supplied (2.54, 2.17 and 2.08 kg, respectively). Wheat bran and linseed cake were given in a significant amount only to lactating cows. Hay was provided mainly to lactating cows and oxen.

Table 11. Mean and standard errors of different feedstuffs provided (kg DM) per day per animal, N=151

Cattle group	Crop Residues	Hay	Wheat bran	Linseed cake	Total DM	%of total
Lactating cows	5.16 ± 0.10	1.64 ± 0.06	1.49 ± 0.08	1.52 ± 0.06	9.80	34.41
None lactating cows	2.15 ± 0.14	0.02 ± 0.01	0.00	0.00	2.17	7.62
Pregnant cows	2.78 ± 0.11	0.21 ± 0.04	0.02 ± 0.01	0.04 ± 0.02	3.06	10.74
None pregnant cows	2.07 ± 0.14	0.01	0.00	0.00	2.08	7.30
Heifers	2.37 ± 0.10	0.16 ± 0.03	0.01	0.01	2.54	8.92
Weaned male calves	0.54 ± 0.02	0.22 ± 0.02	0.02 ± 0.01	0.03 ± 0.01	0.81	2.84
Weaned female calves	0.58 ± 0.03	0.23 ± 0.02	0.03 ± 0.01	0.04 ± 0.01	0.89	3.13
Oxen	4.55 ± 0.09	1.27 ± 0.07	0.03 ± 0.01	0.10 ± 0.03	5.96	20.93
Breeding bulls	0.99 ± 0.17	0.11 ± 0.04	0.03 ± 0.02	0.05 ± 0.03	1.17	4.11

Table 12 indicates the daily nutrient supplied to lactating cows on DM basis. The majority of the DM fed to dairy cows originated from crop residues (52.60%) followed by concentrates (30.68%). On average each household supplied a total of 108.63 MJ of ME, 1150.65 g of CP, 28.69 g of Ca and 37.88 g of P to a lactating cow. Much of the ME (48.59%) and Ca (42.72%) originated from crop residues while concentrates (wheat bran and linseed cake) provided the highest share of CP (63.97%) and phosphorus (77.46%).

Table 12. Mean and standard errors of DM and nutrient supplied to lactating dairy cows

Feedstuff	Quantity supplied per head per day				
	DM (kg)	ME (MJ)	CP (g)	Ca (g)	P (g)
Crop residues	5.16 ± 0.10	52.73 ± 0.52	306.30 ± 0.51	16.41 ± 0.02	5.12 ± 0.02
Hay	1.64 ± 0.06	15.46 ± 0.10	109.44 ± 0.57	5.90 ± 0.04	3.55 ± 0.04
Wheat bran	1.49 ± 0.08	22.30 ± 0.11	476.20 ± 0.08	5.01 ± 0.08	14.46 ± 0.02
Linseed cake	1.52 ± 0.06	18.14 ± 0.10	258.70 ± 0.14	1.37 ± 0.08	14.74 ± 0.04
Total	9.80	108.63	1150.65	28.69	37.88

4.5. Seasonal variability of feed resources

It was generally accepted by all of the respondents that there is seasonal shortage of feed resources. According to the respondents pasture was scarce during the dry season because it dries whereas crop residues, hay and concentrates are scares during both seasons due to insufficiency of production for the first two and cost for the later one. The sampled households practiced feed conservation in the form of hay and crop residues. Concentrate supplementation in almost all of the respondents is not continuously provided; rather it follows the trend of production at agro-industries level.

4.6. Water sources and watering frequencies

The water source in all of the respondents (100 %) is from the rivers, with the watering frequencies of two times per day in dry season (88%) and one time per day in wet season (98.01%). The distances traveled in search of water in all of the respondents were less than one km in 72.19% of the sampled households, one to five km in 27.15% and more than five km in 0.66%.

5. DISCUSSION

The family size found in this study (8.7 persons per household) is very close the report of Solomon (2004) (8.73 persons per household) for the Bale highlands. But it is higher than the finding of Terefe (2007) (6.68 persons), Kelay (2002) (7.54 persons per household) and Getnet (1999) (5-7 persons per household) for the Ethiopian central highlands. The average age of the sampled households in this study was 49.14 years. This result is higher than the report of Solomon (2004) (42.18 years). About 69% of the sampled households in this study had attended primary school and above. This finding is higher than the report of Solomon (2004) for Bale highlands (37.4%), Sisay (2006) (38.5%) for the Gondar area but lower than the report of Terefe (2007) (80%) for the Sululta area in the Ethiopian central highland.

The mean total livestock holding in this study area was 20.44 TLU. This value is higher than the report of Terefe (2007) (15.7 TLU), Gashaw (1992) (10.6 TLU) for the Selale area, Solomon (2004) (10.09 TLU) for the Bale highlands and Solomon (1996) (11 TLU) for the Ethiopian central highlands. This higher value may be due to higher pasture landholding in the present study area. Most of the livestock herd in the study area was composed of cattle (78.86%), which is lower than the finding of Terefe (2007) (85%). The cattle herd size in the current study was dominated by indigenous (60.80%) and cross (39.20%) which is again much lower than the report of Terefe (2007) (60%) in the Sululta and Solomon (1996) (45%) cross in the Selale area.

The share of cows in the cattle herd size in this study was 51.05%. This result is lower than the finding of Terefe (2007) (61.24%) in the Sululta area but higher than the findings of Gashaw (1992) (28%) and Kelay (2002) (38.7- 44%) in the Selale area. The proportion of crossbred in the cow's herd in this study is (46.26%) which is lower than the report of (Terefe, 2007) (71.1%) and (Kelay, 2002) (62-74%).

The objective of cattle keeping in the study area is mainly for milk, draught, income and meat purpose and the result in this study is in agreement with Terefe (2007) for the Sululta area.

Major crops grown in this study area were cereals (barely, wheat, Teff and maize), pulses (faba bean and field pea) and oilseeds (linseed and rape seed). The cereal crops cover about 72.94% of the total land allocated for cultivation. This value is lower than the value found by Terefe (2007) (75%) and Gashaw (1992) (80%) for the Ethiopian central high lands.

The mean total landholding in this study was 6.67 ha per household, which is higher than the result reported by Terefe (2007) (5.77 ha). The mean size of tenured land per household in the present study was (5.46 ha) which is very close to the finding of Solomon (1996) (5.8 ha) for the Ethiopian central highlands, but higher than the result reported by Terefe (2007) (3.46 ha) for Sululta area, Getnet (1999) (3.9 ha) and Kelay (2002) (3.8 ha) for the Ethiopian central highlands. The mean value of contracted land per household for both (crop and pasture) in the current study was 1.21 ha which is lower than the results reported by Terefe (2007) (2.31 ha) and Solomon (1996) (1.7 ha). The average area of land used for pasture by these households was 3.37 ha which is higher than the result reported by Terefe (2007) (2.6 ha) and Solomon (1996) (2.8 ha) for the Sululta and Ethiopia central highlands, respectively.

The major dairy cattle production constraint found in this study was feed, which is in agreement with Alemayehu (2002), Kefena (2004), and Boitumelo and Mahabile (2005) who reported that nutrition is more important constraint to sustaining milk production in Ethiopia than the genetic potential of dairy animals.

The average daily peak milk yield for crossbred and indigenous cows in this study were 6.83 and 2.82 liters, respectively. The peak milk yield for crossbred cows in this study is lower than the result reported by Getnet (1999) (8.01liters) and Terefe (2007) (8.76 liters) in the Ethiopian central highlands and very close to the report of Kiwuwa *et al.* (1983) (6.7 kgs) in Arsi area. The finding of this study for indigenous cows was very close to the result reported by Terefe (2007) (2.58 liters). The mean lactation lengths for crossbred and indigenous cows in this study were 10.3 and 7.49 months, respectively. The lactation length for indigenous in this study is comparable to while that of crosses cows is higher than the results of Terefe (2007) (8.91 and 7.11 months for crossbred and indigenous cows, respectively). Gashaw (1992) also reported a comparable value (10.9 months) for crosses.

Age at first calving in this study was 36.02 months for crosses and 46.77 months for indigenous breeds. The result reported by Terefe (2007) for cross (37.32 months) is comparable to this result while his report for indigenous (50.2 months) is higher. In addition, the finding in this study of age at first calving in crosses is lower than the result report by Yoseph (1999) (49 months). Closer value of age at first calving in indigenous cows was reported by Mukasa-Mugerwa *et al*. (1989) (25 months). The average value of calving interval in the current study was 19.8 months for crosses and 23.53 months for indigenous. These results are longer than the findings of Terefe (2007) (16.2 and 21.67 months for crosses and indigenous cows, respectively). The service per conception in this study was 2.19 and 1.6 times for crosses and indigenous, respectively, which means the conception rate of indigenous is better than crosses.

The feeding systems of cattle in almost all (98.01%) of the sampled households was grazing combined with stall feeding on crop residues and/or other supplements during the morning and evening. This report is higher than that of Terefe (2007), who found 48% households depending only on grazing in the central highlands. The principal feed resources available in the study area were natural pastures, crop residues, agro-industrial by products (linseed cake and wheat bran), some forage crops and fodder trees mainly tagasaste. This finding is in agreement with the report of Zinash *et al*. (1996), Terefe (2007) for the Ethiopian central highlands and Solomon (2004) for the Bale highlands except slight variation on species of improved forages.

Natural pasture was the main feed resource in this study area contributing 58.82% of the total DM available annually in the studied households. This finding is slightly higher than the report of Terefe (2007) and Jutzi *et al*. (1987) (50.17%) in the Ethiopian central highlands. The average size of seasonally water logged and relatively drained pasture lands per household was 1.9 and 1.6 ha respectively. The average yield in this study is 3.65 ton/ha for water logged and 3.60 tons/ha for relatively drained pasture lands. This result on the yield is higher for water logged and lower for drained areas than the report of Terefe (2007) (2.47 and 4.4 tons/ha, respectively). This finding is comparable with the report of Alemayehu (1986) for the water logged (2 to 3 tons) but lower for relatively drained areas (4 to 8 tons/ ha). This result for both water-logged and relatively drained areas is lower than the report of Bayisa (2004) (9.54 to 13.38 tons/ha) for the Sululta area but it is higher than the report of Sisay (2006) (1.2 to 1.8 tons of DM/ha/ year) for the Gondar area.

The contribution of crop residues to the total DM available per household in the study area was 26.26%. This value is higher than the result reported by FAO (1981) (10%) for Ethiopian highlands, Terefe (2007) (11.8%) for Sululta area, but lower than the result reported by Sisay (2006) (46.4%) for the Gondar area, Daniel (1988) (40.50%) for the Ethiopian highlands, and it is comparable to the result reported by Gashaw (1992) (27%) for the Selale area. In this study, the majority of crop residues (85.56 %) originated from cereals. This report is almost similar to the report of Terefe (2007) (88%) for the Sululta area and Gashaw (1992) (80%) for the Selale area.

The contribution of crop aftermath to the total available DM in each household (1.52 tons) was comparable to the report of Terefe (2007) (1.37 tons) for Sululta area but it is higher than that of Sisay (2006) (0.53 tons) in Gondar area of Ethiopia. The total amount of DM obtained from tagasaste per household in this study area was (0.042 ton) and this is much lower than the report of Gashaw (1992) (0.42 tons) but higher than the report of Terefe (2007) (0.02 tons per household). The contribution of concentrates (linseed cake and wheat bran) to the total annual DM in this study was 1.18 tons which was much lower than the result reported by Terefe (2007) (6.53 tons per household). The total amount of dry matter available per TLU in the sampled households was 1.34 ton per annum. This satisfies only 58.77% of the maintenance requirement of DM per annum per TLU. The finding of this study is lower than the report of Terefe (2007) (77.38%) for Selale area.

The botanical composition of natural pastures in this study was dominated by grasses in both water logged and relatively drained areas with their %age composition of 57% and 83% respectively. This report is in agreement with the report of Terefe (2007) (56.45% for water logged and 74.58% for relatively drained). Next to grasses the species composition of natural pasture was covered by sedges which constituted 37% in the water logged and 10% in the relatively drained areas. The proportion of legumes in this study area (3%) is lower than the reports of Adane (2003) and Bayisa (2004) (24.1%) for the highlands of Selale area, Terefe (2007) (16.79%) for Sululta area. This difference might possibly be due to variation in agro ecology and time of sample collection. It has been proved that as harvesting time is delayed, the proportion of legumes decrease radically and the protein content reduce proportionally.

The mean DM of natural pasture in this study was 31.85% for water logged and 32.65% for drained areas. The finding for water logged is higher while that of the relatively drained area is lower than the report of Terefe (2007) (24.56% and 34.47%), respectively. The DM content of natural pasture in water logged areas is lower than drained area in both studies which might be due the water retaining capacity of the water logged area that delay maturity period and had high moisture.

The CP content of natural pasture in this study was found to be 9.28% in seasonally water logged and 8.65% in relatively drained areas. This result is in the range of FAO's (1984) recommendation, that the threshold value of feedstuffs for CP is between 7% and 8%, which is adequate for maintenance of livestock and above the minimum requirement for optimum rumen function (7.5%) suggested by Van Soest (1982). The CP value for drained pasture land in this study is higher than the result reported by Kidane (1993) (7.3%) and Terefe (2007) (7.53%) for the Ethiopian central highlands. The CP content of pasture species in the water logged area in this study is higher than in the drained probably for the same reason mentioned above for DM content. It has been established that maturity age and CP content are inversely related.

The CP content of barley, wheat, faba bean and field pea straws in this study were 5.73%, 4.10%, 6.67%, and 7.24%, respectively. The values found for barley, wheat and bean straw in this study are lower as compared to the result reported by Terefe (2007) (5.96%, 5.36% and 8.88%, respectively). But some of the results in this study are higher than the results reported by Seyoum and Zinash (1989) (4.4% for barley and 2.42% for wheat straws), Gashaw (1992) (3.6% for barely and 2.7% for wheat straws), Lulseged and Jamal (1989) (4.7% for barley and 3.9% for wheat).

The CP content for hay in this study was 6.67% which is almost similar to the results reported by Gashaw (1992) (6.79%) for the Selale area, Lulseged and Jamal (1989) (6.6%) and Seyoum and Zinash (1989) (6.2%) for the Ethiopian highlands, This result, however, is higher than the result reported by Anderson (1987), who stated that CP content in harvested hay seldom exceeds 5% in the central Ethiopia highlands. Nevertheless, the present result is still below the minimum level for optimum rumen function of CP (7.5%) suggested by Vansoest (1982). This low CP content is generally believed to be the most common characteristics of the mature tropical forages whose protein content decline rapidly following the rapid growth period of the rainy season.

The CP content of linseed cake in this study was 31.96%, which is higher than the result reported by Abebe (2006) (26.77%) but lower than the result reported by Cheeke (1991) (35%). CP content of wheat bran in this study was (17.02%) which is in agreement to the result reported by Cheeke (1991) (17%), higher than the result reported by Terefe (2007) (15.75%) for the Sululta area, Aynalem *et al.* (1999) and Aboud *et al* (1994) (16.9%), but it is lower than the result reported by Alemu and Guenther (1992) (18.36%).

The CP content of tagasaste in this study was (15.6%) which is lower than the result reported by Gashaw (1992) (18.15%) in the Selale area, Terefe (2007) (16.1%) in the Sululta area, Debele (2000) (24.07%) for the Degem in Selale area and Seyoum (1995) (21%) for browse species. The possible explanation for the lower CP content of tagasaste in this study might be due to late time of harvest (January), lack of regular cut for use, variations in agro ecology, soil nature, and other environmental factors.

The ME content of natural pasture in water logged and relatively drained areas were 10.51 and 10.46 MJ/kg DM, respectively. The results in this study are in agreement with the result reported by Gashaw (1992) (10.70 MJ/ kg DM) for green pasture in Selale area but it is slightly higher than the result reported by Terefe (2007) (9.27% for water logged and 9.25% for relatively drained areas) in Sululta area. The average ME of crop residues in this study (barley, wheat, faba bean and field pea straws were 10.57, 10.30, 10.35 and 9.66 MJ/kg DM, respectively. This result is higher than the result reported by Terefe (2007) (6.53 to 8.75 MJ/kg DM) in the Sululta area, Lulseged and Jamal (1989) (6.8 MJ/kg DM) for the Ethiopian highlands. The average ME of hay in this study was 9.43 MJ/kg DM, which is lower than the result reported by Gashaw (1992) (10.2 MJ/kg DM) for the Selale area but higher than the result reported by Seyoum and Zinash (1989) (6.6 to 8.4 MJ/kg DM) and Daniel (1990) (8.9 MJ/kg DM) for the Ethiopian central highlands. The average ME of linseed cake in this study was 12.17 MJ/kg DM, while that of wheat bran was 14.67 MJ/kg DM. The result for wheat bran in this study is higher than the result reported by Terefe (2007) (13.79 MJ/kg DM), Aynalem *et al.,* (1999) and Aboud *et al.,* (1994) (10 MJ/kg DM). The variation in chemical composition and nutritive value of agro-industrialby products might be due to species of the plants and methods of processing (Seyoum, 1995). The average ME of tagasaste in this study was 7.34 MJ/kg DM, which is comparable to the result reported by Terefe (2007) (7.8 MJ/kg DM) but lower than the result reported by Gashaw (1992) (10.4 MJ/kg DM).

The NDF content of natural pastures on average was 66.53% for water logged and 66.65% for relatively drained. This result is higher than the finding of Terefe (2007) (62.2% for water logged and 64.09% for drained areas) of Sululta area, Adane (2003) (57.7%), Kidane (1993) (63.4%) in the central Ethiopian highlands. NDF above 55% can limit the DM intake (Vansoest, 1967). The NDF content of crop residues (barley, wheat, faba bean and field pea) was (73.66%, 74.53%, 62.11% and 62.65%) respectively. Some of these results are lower than the result reported by Terefe (2007) (76.71% for barley, and 78.06% for wheat straws), Sisay (2006) (72.35-84%) in Gondar area, Solomon (2004) (75.06% for barley, 78.62% for wheat and 72.98% for field pea). The value for faba bean in this study is higher than that of Solomon (2004) (59.23%) for bale high lands. The NDF contents of all crop residues in this study are beyond the limit of 55% and hence could hinder DM intake (Vansoest, 1967). The average NDF content of hay in this study was 67.47% which is higher than the result reported by Gashaw (1992) (65.01%) for native pasture in Selale area but lower than the finding of Ahmed (2006) (79.08%) in North Shoa of Bosana Wereda. The NDF content of linseed cake and wheat bran in this study were 31.59% and 23.21%, respectively; the result in wheat bran of this study is comparable to the result of Terefe (2007) (22.11%). The average NDF obtained from tagasaste in this study was 61.71%, which is lower that the result obtained by Terefe (2007) (72.74%) for the Sululta area, but higher than the result reported by Gashaw (1992) (39.86%).

ADF is widely used for measuring the fiber in feeds, often substituting for crude fiber, which is used in the proximate analysis of feeds. The acid soluble fraction included primarily hemicelluloses and cell wall proteins, while the residue recovers cellulose and the list digestible non carbohydrate fractions. Acid detergent has the advantage of removing substances that interfere with the estimation of refractory components so that ADF residue is useful for the sequential estimation of lignin, cutin, cellulose, indigestible Nitrogen and Silica (Van Soest, 1982). The ADF content of natural pastures in the current study was 39.76 % for water logged and 40.54% for the drained areas. The result of this study was comparable to the result reported by Terefe (2007) (36.76%) for water logged and (39.01%) for the drained areas. This is again within the range of the result reported by Adane (2003) (24.5 to 42.9%). Kidane (1993) reported the ADF content range of 35.1 to 41.4% for pasture in the Selale area. The ADF content of crop residues obtained in this study was 45.35% for barley, 49.25% for wheat, 51.09% for faba bean and 51.73% for field pea. Some of the results in this study were comparable to the result reported by Terefe (2007) (46.2% for barley straw) but higher than the result of the same author (46.3% for wheat straw). The ADF content of wheat straw in this study was close to the finding of Solomon (2004) (47.58%). The ADF values for faba bean in this study was higher than the report of Solomon (2004) (46.81%) while that of barley and field pea were lower than the reports of the same author (49.46% for barley and 57.32% for field pea). The ADF content of hay in this study was 41.31% and this is higher than the results reported by Getnet (2007) (38.36%) and lower than the result reported by Ahmed (2006) (46.65%). The ADF Content of concentrates in this study was 20.57% for linseed cake and 11% for wheat bran. The result for wheat bran in this study is close to the finding of Terefe (2007) (9.98%). The ADF content of tagasaste in this study was (25.65%). This result is slightly lower than the result reported by Terefe (2007) (27.53%) for Sululta area but higher than that of Getnet (2007) (22.09%) for Holeta area.

The calcium (Ca) content of natural pasture in this study was 0.29% for water logged and 0.33% for relatively drained. This result is higher than the result reported by Terefe (2007) (0.13%) for the Sululta area, but lower than the result reported by Kidane (1993) (0.55%) in Ethiopian central highlands. And the phosphorous (P) content of pastures in this study was (0.19% for water logged and 0.23% for the relatively drained pasturelands), which are lower than the results reported by Terefe (2007) (0.23 to 0.34%, respectively). The value for relatively drained area is very close to the finding of Kidane (1993) (0.24%), and both values are within the range reported by ARC (1980) (0.11 to 0.34%). The lower phosphorous content is observed with the advancing days of harvest Adane (2003). Minson (1982) reasoned out that the decrease in phosphorous content as the age of pasture advances might be due to the translocation of the element to the seeds and root parts of the herbage. According to Little (1982), the mineral concentrations in forages are dependant upon the interaction of a number of factors such as soil, plant species, stage of maturity and climate.

The Ca and phosphorous content of crop residues (barley, wheat, faba bean and field pea) were 0.23 and 0.07, 0.15 and 0.07, 0.40 and 0.13 and 0.49 and 0.13 %, respectively. Some of these results were not in agreement with Terefe (2007) (0.05 and 0.34% for barley and 0.03 and 0.02% for wheat, respectively). The Ca and phosphorous contents of concentrates (linseed cake and wheat bran) in this study were 0.34 and 0.97% for linseed cake and 0.09 and 0.97% for wheat bran) that indicates wheat bran has lower Ca content but its phosphorous content is similar to linseed cake. This result is higher than the result reported by Terefe (2007) for wheat bran (0.02% Ca and 0.06% phosphorous). The Ca and P contents of tagasaste in this study were 0.47% and 0.22%, respectively. This result is higher for Ca and lower for phosphorous when compared to the result reported by Terefe (2007) (0.18 and 0.4 %, respectively).

The average amount of DM daily supplied to dairy cows in this study was 9.80 kg which is lower than the result reported by Terefe (2007) (12.42 kg). The majority of the DM fed to the dairy cows in this study originated from crop residues (52.65%) followed by concentrate (30.71%), which is not in agreement with the result reported by Terefe (2007) (36.6% hay) and Kelay and Peters (2006) (51.1% hay), where in both cases hay constitutes the most important feed resource for dairy cattle.

The quantity and quality of feeds supplied to animals vary markedly over the seasons. Agro-industrial by-products supplied were not given consistently through our the year, in most of the households, rather they follow production trend which is in agreement with the findings of Terefe (2007) for the Sululta area, Gashaw (1992) for the Selale area and Ahmed (2006) for Bosana Wereda of North Shoa.

The water source in all of the respondents in the study area was from rivers with the watering frequency of two times in a day in majority of the respondents and the distance traveled in search of water being less than one km. This is almost similar to the report of Ahmed (2006).

6. CONCLUSIONS AND RECOMMENDATIONS

The major dairy cattle feed resources in the study area were natural pasture, crop residues, hay, concentrates, crop aftermath and forage trees mainly tagasaste. Natural pasture was the most important feed resource contributing to more than half of the total DM available per annum in the studied households followed by crop residues. The total available feed (DM) per TLU per day in the study area was in shortage of meeting even the maintenance requirement.

The CP content of natural pasture was fairly good and is within the range of the threshold values for maintenance requirement of tropical livestock (above the minimum requirement for optimum rumen function). However the CP content of crop residues and hay is much lower than the minimum requirement for the optimum rumen function. The CP content of linseed cake, wheat bran and tagasaste were much higher than the CP required for the optimum rumen function. The ME content of all the major feed resources in the study area was poor.

Feed resources such as natural pastures, crop residues, hay and tagasaste had high NDF and ADF contents and this high content is an indication of poor quality roughages that limit voluntary feed intake and reduce animal productivity.

The amount of DM, CP and ME supplied to dairy cows were under the daily maintenance and production requirements.

Based on these findings and conclusions, the following recommendations are forwarded:

- ❖ Complementary strategy of nutrient balance through supplementation, using high yielding improved forages and pasture crops, treatment of crop residues (physical treatments like chopping, wetting and chemical treatments like ensiling with urea and molasses) should be encouraged and awareness be created;
- ❖ The utilization of tree legumes as animal feed is minimal in the study area, so attention should be given to make them aware of the utilization of these feed resources;

- Systematic screening of botanical composition of natural pasture and forage crops should be given emphasis and future research should be carried out on selection and development of indigenous and/or exotic origin species of forage and pasture feed resources suitable for the study area.

7. REFERENCES

Abate, T., Teferra, G., Alemu, G., Biruk, Y. and Philip, C. (1989): Status of dairying in Ethiopia and strategies for future development. In: Proceedings of 3rd Livestock Improvement Conference, 24-26 May, 1989, Addis Ababa, Ethiopia.

Abebe, T. (2006): Supplementation with Linseed (*Linum Usitatissimum)* Cake, Wheat Bran and Their Mixtures on Feed Utilization, Live Weight Changes in Intact Male Arsi-Bale Sheep. MSc Thesis, Haramaya University, Ethiopia.18p

Aboud, E., Owen, J., Reed, D. and Said, A.N. (1994): Influence of amount of feed offered on growth, intake and selectivity: observations on sheep and goats. In: Lebbie, S.H.B., Rey, B. and Irungru, E.K. (eds), Small Ruminant Research and Development in Africa, Proceeding of the Second Biennial Conference of the African Small Ruminant Research Network, 7-11 December, 1992, AICC, Arusha, Tanzania.

Abule, E., (1994): Performance of Cross Bred Calves Fed Teff Straw Supplemented With Graded Level of Cow Pea and Dolichos Lablab Hay. MSc Thesis, Alemaya University of Agriculture, Ethiopia.

Adane, K. (2003): Effect of Harvesting and Fertilizer Application on Dry Matter Yield and Quality of Natural Grass Land in Highlands of North Shoa, Oromia, Region. MSc Thesis, Alemaya University, Alemaya, Ethiopia.

Adisu, L. (2008): Land Access and Constraints to Rural Land Contracts in Arsi: The Case of Lemu-Bilbilo District. MSc Thesis, Haramaya University, Ethiopia.27p.

Adugna, T. (1990): Animal Production and Feed Resource Constraints In Welayta Sodo and The Supplementary Value of Desmodium Intortum, Stylosanthes Guiensis and Stover, MSc, Thesis, Agricultural University of Norway, Norway.

Ahmed H., (2002**):** Assessment of spatial variability of some physicochemical properties of soils under different elevation and land use systems in western slope of mount Chilalo, Arsi. MSc. Thesis. Alemaya University.

Ahmed, H. (2006): Assessment and utilization practices of feed resources in Bosana Werana Wereda of North Shoa. MSc Thesis, Haramaya- University, Ethiopia. Pp1-93.

Alemayehu, M. (1985): Feed resource in Ethiopia. In: Proceedings of a Workshop on Animal Feed Source for Small Scale Livestock Producers, 11-15 November 1985, Nairobi, Kenya.

Alemayehu, M. (1986): Pasture Research and Development in Ethiopia. FNE Newsletter, No.2, ILCA, Ethiopia, Pp24-32.

Alemayehu, M. (1998): Natural Pasture Improvement Study Around Small Holder Dairy Areas. Smallholder Diary Development Project (SDDP), MOA, Addis Ababa, Ethiopia.

Alemayehu, M. (2002): Forage Production in Ethiopia: a Case Study with Implications for Livestock Production. Ethiopia Society of Animal Production (ESAP), Addis Ababa, Ethiopia.

Alemayehu, M. (2004): Participatory innovation and research lesson for livestock development. In: Proceedings of the 12th Conference of the Ethiopian Society of Animals Production (ESAP), August 12-14, 2004, Addis Ababa, Ethiopia, Pp 251-259.

Alemu, G., Alemayehu, M., Sendros, D., Seyoum, B. and Alemu, T. (1998): Status of dairy research in Ethiopia: prospects for improving dairying in Ethiopia. In: Proceedings of a Workshop on the Role of Village Dairy Cooperatives in Dairy Development, 22-24 April, 1998, Ministry of Agriculture, Addis Ababa, Ethiopia, Pp 74.

Alemu, Y., Zinash, S., and Seyoum, B. (1989): The potentials of crop residues and agro-industrial by-products as animal feed. In: Proceedings of the 3rd Livestock Improvement Conference, 24-26 May 1989, IAR, Addis Ababa, Ethiopia.

Alemu,Y. and Guenther,K. D. (1992): Studies on the chemical composition of some poultry feeds of Ethiopian origin. *Beitr.Trop.Landwirtsch.Vet.Med*, **30**(40):427-450.

Anderson, F. M., (1987): Farmer circumstances in Ethiopia and the improvement of animal feed resources. pp. 209-219. In: J. A. Kategile, A. N. Said and H. D. Dzowela (eds.). Animal Feed Resources for Small-scale Livestock Products. Proceeding of the 2nd Pastures Network for Eastern and Southern Africa (PANESA) Workshop Held in Nairobi, Kenya, November 11-15, 1985.

AOAC, (Association of Agricultural Chemists) (1980): Official Method of Analysis 12th ed., Arlington, Virginia, Washington DC, USA. Pp 957.

ARC (1980): The Nutrient Requirement of Ruminant Livestock. Common Wealth Agricultural Bureaux, Farnham Royal, London, U.K.

Assefa, T. (1990): Livestock development in peasant sector of Ethiopian highland. Some policy issues and implications. ALPAN Network Papers No. 24, ILCA, Addis Ababa, Ethiopia, 1990.

Aynalem, S. Tembly, D. O., Anindo, J., Rege, E. O., Mukasa-Megrewa, E., Alemu, Y. and Baker, R. L. (1999): Effect of dietary protein supplementation on resistance of lambs to artificial infection with Haemonchus cotortus, preliminary results. In: Proceeding of the Sixth Annual Conference of the Ethiopian Society of Animal Production, 14-15 May 1998, Addis Ababa, Ethiopia.

Azage, T., Tesfu, K. and Mukassa-Mugrewa, E. (1995): Aspects of bull reproduction with emphasis on cattle in Ethiopia. I. Sexual development and onset of puberty. In: Proceedings of Ethiopian Society of Animal Production, 27-29 April 1994, Addis Ababa, Ethiopia, Pp 43-55.

Azage, T., Workneh, A., Berhanu, G., and Salvador, F. R. (2002): Opportunities for improving dairy production in Ethiopia. In: Asefa, A., Getachew, T. and Johann, B. (eds). In: Resource Management for Poverty Reduction: Approaches and Technologies, Addis Ababa, Ethiopia. Pp107-121.

Bayisa, H., (2004): Determination of Botanical Composition of Native Pasture at Adaberga and Sululta-mulo Districts Using PHYGROW Frame. HARC, Holeta, Ethiopia.

Boitumelo, W. S., and Mahabile, W. (2005): Improving Milk Production in Small-scale Dairy Farms in Botswana: Incorporating Legume Fodder in the Farming Systems. http://www.fao.org/Wairdocs/ILRI/x5519B/x5519b1e.htm. 353.

Brannang, E. and S. Person, (1990):Ethiopian Animal Husbandry. A Handbook, Southeast Agricultural Development Zone, Uppsala, Pp 45-72.

Cheeke, P. R. (1991): Applied Animal Nutrition. Feeds and Feeding. Macmillan, New York and Toronto, Pp 54-504.

Chenost, M. and Sansoucy, R. (1989):Nutritional characteristic for tropical feed resources: natural and improved grasslands, crop residues and agro-industrial by-products In: Andrew, S. and Rene, S. (eds), Feeding Dairy Cows in the Tropics, Animal Production and Health Paper 86, Proceedings of the FAO Expert Consultation, 7-11 July 1989, Bangkok, Thailand, Pp 66-81. FAO.1991, Rome, Italy.

Coaldrake, J.E., J.C. Tothill, and P.G. Hard, (1976): Natural vegetation and pasture research. Pasture research principles and methods. Common wealth Agricultural Bureax, Bull No.**51.** Farnham, Royal, Bucks, England.

Coffey, R.E, Pearson, L.W, Douglass and R.H. Miller, (1982): Methods of estimating energy intake by production traits and body weight. Journal of dairy science.65, 2102 -2110.

Cottnie, A. (1980): Soil and Plant Testing as Bases of Fertilizer Recommendation. FAO, Soils Bulletin, No.38/2, Rome, Italy, Pp 94-97.

Daniel, K. (1988): Role of crop residues as livestock feed in Ethiopian highlands. In: B.H.; Dzowela (Ed). African forage plant genetic resources, evaluation of forage germPlasm and extensive livestock production systems. Proceedings of the third PANESA (Pastures Network for Eastern and Southern Africa) workshop held at Arusha, Tanzania, 27-30 April, 1987.Pp.430-439.

Daniel, K. and Tesfaye, K. (1996): Oromia Livestock Development Strategy. Livestock Production Department, Addis Ababa, Ethiopia.

Daniel, K., (1990): Effect of management practices on Rhodes grass/Lucerne pastures with special reference to developmental stage at cutting and associated changes in nutritional quality. In: Dzowela, B.H., Said, A.N., Asrat, W., and Kategile, J. A. (eds), Utilization of Research Results on Forage and Agricultural By-products, Proceedings of the First PANESA/ARNAB Joint Workshop, 5-9 December 1988, Lilongwe, Malawi, International Livestock Center for Africa (ILCA), Addis Ababa, Ethiopia, Pp 104-113.

Debele, B., (2000): Effect of Feeding Tagasaste (*Chamaecytisus palmensis)* on Feed Intake, Digestibility and Growth Performance of Indigenous Sheep Fed on Native Grass Hay. MSc thesis, Alemaya University of Agriculture, Alemaya, Ethiopia.

Devendra, C. (1990): Shrubs and Trees Fodders for Farm Animals. International Development Center, Ottawa, Canada, 349p.

Dzowela, B. H. (1990): Preamble to the meeting. In: Dzowela, B. H., Said, A. N., Asrat, W. and Ketegile, J. A. (eds), Utilization of Research Results on Forage and Agricultural By-products Materials and Animal Feed Resources in Africa, Proceedings of The First Joint Workshop, 5-6 December 1988, Lilongwe, Malawi, Pp 2-4.

EIAR (Ethiopian Institute of Agricultural research) (2007). Laboratory Procedures for feed evaluation, Addis Ababa, Ethiopia.

Ensminger, M.E., Oldfield, E. J. and Hernemann, W. W. (1990): Feed and Nutrition. 2nd ed., Ensminger Publishing Company, California, USA, pp 1511.

FAO (1981): International Scheme for the Coordination of Dairy Development and International Meat Development Scheme. Report of the Mission to Ethiopia, 27 May-28 June 1980, FAO, Rome, Italy.

FAO (1984): Assistance to Land Use Planning of Ethiopia, Livestock and Feed Resources. UNDP/FAO Technical Report 6, FAO, Rome, Italy.

FAO (1986): Ethiopian Highlands Reclamation Study. Final Report Volume 1, FAO, Rome .Italy.

FAO (food and Agriculture organization of the united nation), (1987): Master land use plane Ethiopian Range land/livestock consultancy Report prepared for the government of the people Democratic republic of Ethiopia. Technical reportAG/ETH/82.020/FAO, Rome, Italy. Pp 94.

Faye, B. (1981): Prediction of Nutritive Value of Tropical Forage. National Veterinary Institute, Debre Zeit, Ethiopia.

Freeman, H. A., Jabar, M. A. and Simeon, K., (1998): Role of Credit in the Uptake and Productivity of Improved Dairy Technologies in Sub Saharan Africa. Socioeconomic and Policy Research Working Paper No. 22, Livestock Policy Analysis Project, ILRI**.** Addis Ababa, Ethiopia.

Gashaw, G. (1992): Assessment of Feed Resources Base and Performance of Cross Bred Dairy Cows Distributed to the Small Holder in the Selale Development Project Area. MSc Thesis, Alemaya University of Agriculture, Ethiopia.

Getachew, A., Haile, B., Workneh, N. and Gezahegn, A. (1993): A Survey of the Farming Systems of Vertisol Areas of the Ethiopian Highlands. Synthesis Report 1986-92, Technical Committee of the Joint Vertisol Project, Addis Ababa, Ethiopia, Pp 29-49.

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. MSc Thesis, Swedish University of Agricultural Science, Uppsala, Sweden.

Getnet, A., (2007): Evaluation of Tagasaste (chamaecytisus palmentis) as forage for ruminants. PhD Dissertation, Verlg, D.r Koster. Berlin. pp 20.

Goering, J.K. and Van Soest, P.J., (1970): *Forage Fibre Analysis* (Apparatus, reagents, procedure and some Applications) Agricultural Hand Book No. 379. Agricultural Research Crevice, United States Department of Agriculture, Washington DC. Pp. 1-20.

Gryseels, G. and Anderson, F. M. (1983): Research on Farm and Livestock Productivity in the Central Highlands: Initial Results. 1977-1980 ILCA Research Report No.4, ILCA, Addis Ababa, Ethiopia, Pp 52.

IAR (Institute of Agricultural Research) (1983): Annual Report, Addis Ababa, Ethiopia. Feed Resource Base of Ethiopia: Status, Limitations and Opportunities for Integrated Development. IAR, Addis Ababa, Ethiopia.

Ibrahim, K. M. (1981) Shrubs for Fodder Production. In: Advances in Food Producing Systems for Arid and Semi Arid Lands, Academic Press Inc., Pp 601-643.

ILCA (International Livestock Center for Africa) (1979): Small Ruminant Production in the Humid Tropics. System Study No.3, ILCA, Addis Ababa, Ethiopia, pp 49-54.

John C. (1992): Assessing the quality of food: In Ruminant Nutrition. The tropical Agriculturalist Macmillan. Malaysia, Pp 155- 158.

Jutzi,S., Heque,I. and Abate,T., (1987): The production of animal feed in Ethiopian high lands, potentials and limitations. In: IAR Proceeding, First National Livestock Improvement Conference, 11-13 February 1987, Addis Ababa, Ethiopia, Pp141-142.

Kabaija, E. and Little, D. A. (1988): Nutrient quality of forages in Ethiopian with particular references to evaluation of forage germplasm in extensive livestock production systems. In: Proceedings of the 3rd PANESA Workshop, 27-30 April 1987, Arusha, Tanzania, Pp 440-448.

KARC (Kulumsa Agricultural Research center), (2001): Annual report of kulumsa Agricultural research center, Asela, Ethiopia PP.6.

Kearl, L.C (1982): Nutrient requirement of Ruminants in developing countries international feedstuffs institute, Utah Agricultural experiment station, Utah state university 84332.USA, pp381.

Kefena Effe, (2004): Analysis of Longevity, Productive Herd Life and Lifetime Production of Boran Crossbred Cows with Various Levels of Exotic Inheritance in the Central Highland of Ethiopia. MSc Thesis, Alemaya University.

Kelay B., (2002): Analysis of Dairy Cattle Breeding Practices in Selected Areas Of Ethiopia. PhD Thesis, Humboldt University of Berlin, Department of Breeding in the Tropics and Sub Tropics, Berlin, Germany.

Kelay, B. and Peters, K.J., (2006): Dairy cattle feeding practices in the highlands of Ethiopia. *Bull.Anim.Hlth.prod. Afr.*, **54:**186-192.

Kidane, G., (1993): Effect of Stage of Harvest on Botanical Composition and Feeding Value of Native Pasture in the Ethiopian Central Highlands. MSc Thesis, Alemaya University of Agriculture, Ethiopia.

Kiwuwa, G.H., Trial, J.C.M., Kurtu, M.Y., Getachew W., Anderson, F.M. and Durkin, J. (1983): Cross bred dairy cattle productivity in arsi region, Ethiopia. ILCA Research Report No.11. International Livestock Center for Africa, Addis Ababa Ethiopia, Pp28.

L'timannetje, (1978): Measuring quantity of Grassland Vegetation. Pp. 63-91. In: L'timannetje (ed.) Measurements of Grass land Vegetation and Animal Production. Bulletin of common Wealth Bureau of Pasture and field Crops, No. 52. Common Wealth Agricultural Bureau, Hurley (UK).

LBWARDO, (2005): (Lemu and Bilbilo wereda Agricultural and Development Office) Annual report, Bekoji, Ethiopia.

LBWARDO, (2006): (Lemu and Bilbilo wereda Agricultural and Development Office) Annual report, Bekoji, Ethiopia.

LBWARDO, (2007): (Lemu and Bilbilo wereda Agricultural and Rural Development Office) Annual report. Bekoji, Ethiopia.

Little, D. A. (1982): Utilization of minerals. Nutritional limits to Animal Production from Pastures. In: Hacker, J. B (ed), Proceeding of the International Workshop, 24 -28 August 1981, St.Lucia, Queensland, Australia, Pp 259-283.

Lulseged, G. and Jamal, M. (1989): The potential of crop residues, particularly wheat straw, as livestock feed in Ethiopia. In: Said, A. N. and Dzowela, B. H. (eds), Overcoming Constraints to the Efficient Utilization of Agricultural By-products as Animal Feed, Proceedings of the Fourth ARNAB (African Research Network for Agricultural By-products) Workshop, 20-27 October 1987, Institute of Animal Research, Mankon Station, Bamenda, Cameron.

Lulseged, G., (1987): The status of pasture and forage research in Ethiopia. In: Proceedings of the National Workshop on Livestock, Pasture and Forage Research in Ethiopia, 8-19 January, 1985, Institute of Agricultural Research, Addis Ababa, Ethiopia, Pp 101-113.

Mc Donald, P., Edwards R. A., and Green, H. (1988): Voluntary intake of food. In: Animal Nutrition, 4th ed., Longman Inc, London, UK, 543p.

Mc Donald, P., Edwards, R. A. and Green, H. (1982): Grass and forage crops. In: Animal Nutrition, 3rd ed., Longman Inc., New York, Pp 353-354.

Mc Donald, P., Edwards, R. A., Green, H. and Morgan, C. A. (1995): Animal Nutrition5th ed. Longman Group, Harlow, UK, 288-607p.

McDonald, P., Edwards, R. A., Green, J. F. D. and Morgan, C.A. (2002): Animal Nutrition, 6th ed, Prentice Hall, London, Pp 583-585.

Microsoft Office Excel (2003): Microsoft Corporation 2003 (11-5612-5606)

Minson, D. J. (1982): The Chemical Composition and Nutritive Value of Tropical Forage Legumes. FAO Plant Production Series 2, FAO, Rome, Italy, Pp218.

Mitiku, G. (2004): Livestock Export Marketing: Analysis of Existing Situation and Challenges. Prepared for FAO- Ethiopia Office, Addis Ababa, Ethiopia.

MOA, (1998): Small Holders Dairy Development Project (SDDP). In: Proceedings a Workshop on Role of Village Cooperatives in Dairy Development, Prospect for improving Dairy in Ethiopia, 22-24 April, MOA, Addis Ababa, Ethiopia.

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

Moog, R. A. (1989): Forage and legume as protein supplements for pasture based systems. Animal Production and Health Paper 86, FAO, Rome, pp 142-148.

Mukasa-Mugerwa E. D, Ephrem, B. and Taddese T., (1989): Type and productivity of indigenous cattle in Central Ethiopia. *Tropical Animal Health and Production*, **21:**120.

OBPED (Oromia Bureau of Planning and Economic Development), (2001): Sub-Regional Atlas of Central Oromia, Physical Planning Department, Finfinne. As cited by Adisu Likassa, MSc, Thesis, Haramaya University December, 2007.

Petmak, M.V., (1983): Primary productivity, Nutrient cycling and OM turn over of tree plantation after Agricultural intercropping practices in North east Thailand. PhD thesis, University of Philippines, Los Banos, Philippines. Pp 22.

Rangnekar, D. V. (1992): Fodder trees as a renewable energy source for biomass quantification. In: Speedy, A. and Pugliese, P. L. (eds), Legume Trees and Other Fodder Trees as Protein Sources for Livestock, Animal Production and Health Paper, No.102, Pp 309-315.

Ranjhan, S. K. (1993): Animal Nutrition in the Tropics. 3rd ed., Vikas Publishing House PVT LTD, New Delhi, India.

Reed, J. D, Abate, T. and Jutzi, S. (1986): Large differences in digestibility of crop residues from sorghum varieties. ILCA Newsletter, Volume 1, Number 1, Pp 5-6.

Samuel M., (2005): Characterization of live stock production system potential, constraints and intervention strategies: A case study of yerer watershed, Adaliben district of east Showa, Ethiopia. MSc. Thesis, Alemaya University, Diredawa, Ethiopia.

Seyoum, B. and Zinash, S. 1989): The Composition of Ethiopian Feeds. Research Report No. 6. , Institute of Agricultural Research, Addis Ababa, Ethiopia.

Seyoum, B., (1995): Evaluation of Nutritive Values of Herbaceous Legumes, Fodder Trees and Oil Seed Cakes Using Chemical Analysis In-vitro Digestibility and Nylon Bag Technique. MSc Thesis, Alemaya University of Agriculture, Alemaya, Ethiopia.

Shenkute, T. (1972): Nutritional Value of Some Tropical Grass Species Compared to Some Temperate Grass Species. PhD Thesis, Cornel University, Ithaca, New York.

Sisay, A., (2006): Qualitative and Quantitative Aspects of Animal Feed in Different Agro-ecological Area of North Gondar. MSc Thesis, Alemaya University, Alemaya, Ethiopia.

Sniffenen, C.J., R.W Beverly, C.S. Mooney, M.B. Roe, A.L. Skid more and J.R. Black, (1993): Nutrient requirement versus supply in the dairy cows. Strategies to account for variability Journal of dairy science **76**:33160 -3178.

Solomon, B. (2004): Assessment of Livestock Production Systems and Feed Resource Base in Sinana Dinsho District of Bale Highlands Southeast of Oromia. MSc Thesis, Alemaya University, Ethiopia. Pp15-101.

Solomon, M. (1996): On Farm Feeding Management and Production Performance on Cross Breed Dairy Cows in the Selale Area (Central Ethiopian Highlands). MSc Thesis, Alemaya University of Agriculture, Alemaya, Ethiopia.

SPSS, (2003): Statistical packages for social sciences. Version 12.01. SPSS.

Stoddart, L. A and Smith, A. P. and Box, T. W. (1975): Range Management. 3rd ed., McGraw- Hill Book Inc., New York, 532p.

Taylor, M. S. (1984): Assistance To Land Use Planning In Ethiopia, Livestock And Feed Resource; Technical Report No.6, FAO, Rome, Italy, 71P.

Terefe B., (2007): Assessment of Available Feed Resources for Dairy Cattle in the Sululta District, North Shoa Zone of Oromia. MSc Thesis, AAU-FVM, Debrezeit, Ethiopia.

Tesfaye, A. (1999): The Role of Crop Residues as Livestock Feed Resources in Semi-arid Areas of Adamitulu District, Ethiopia. MSc Thesis, University of Nairobi, Kenya.

Tilley and terry, (1963): A two stage technique for the in-vitro digestion of forage crops. J.Br. Grass land Soc., **18**: 104-111.

Tothill, J.C., Jone, R.M. and Hargreaves, N.G., (1978): BATANAL: a field and computing package for assessment of plant biomass and botanical composition Ecology and management of world savannas.pp.399.

Van Soest, P. J. (1967): Development of a comprehensive system of feed analysis and its application to forage. *Journal of Dairy Science*, **48**: 818.

Van Soest, P. J. (1982): Ruminant metabolism, nutritional strategies, cellulose fermentation and the chemistry of forages and plant fibers. In: Nutritional Ecology of the Ruminant, Comstock Publishing Associates, Cornell University Press, London, Pp23-27.

Varviko, T., (1991): Nutritional constraints of improved small holder milk production in the Ethiopian high lands: the Selale experience: in proceedings of the fourth national livestock improvement conference, 13-15 November, 1991, Addis Ababa, Ethiopia. PP45-50

Wilson, A. D. (1977): The digestibility and voluntary intake of the leaves of trees and shrubs by sheep and goats. *Australian Journal of Agricultural Research*, **28**(3): 501-508.

Winrock International (1992): Assessment of Animal Agriculture in Sub Saharan Africa, Winrock International, Morriolton, Arkansas.

Yitaye A., Azage T., and M.Y kurtu, (2000): The livestock production systems in three peasant associations of the Awassa wereda. In proceeding of 8th Annual conference of the Ethiopia. Society of Animal production (ESAP) may 2000. Addis Ababa, Ethiopia PP 155-166.

Yoseph, M., (1999): Impact of feed resources on productive and reproductive performance of dairy cows in the peri-urban dairy production systems in the Addis Ababa milk shed and evaluation of non-conventional feed resources using sheep .MSc Thesis, Alemaya University of Agriculture, Diredawa, Ethiopia.

Zinash, S. and Seyoum, B. (1991): Utilization of feed resources and feeding systems in the central zone of Ethiopia. In: Proceedings of the Third National Livestock Improvement Conference, 24-26 May 1989, IAR, Addis Ababa, Ethiopia, Pp 129-132.

Zinash, S., Seyoum, B., Hailu, G. and Daniel, K., (1996): Aspects of variet als development and release in forage and pasture crops in Ethiopia. In: Proceedings of the 4th National Livestock Improvement Conference of Ethiopian Society of Animal Production, Addis Ababa, Pp57-68.

Zinash S., Tesfaye, K., Azage T. and Osuji, P. (1998): The regional Livestock Early Warning System (LEWS) Project: the contribution and role of Ethiopia. In: Proceedings of the National Workshop on Early Warning System and Monitoring Livestock Nutrition and Health, 4 February 1998, Texas A and M University and EARO, Addis Ababa, Ethiopia.

8. ANNEXES

Annex 1Questionnaires Format

Date of interview ____/__/____ Sample code No_______ Keble________________________

I. Survey site (Location)

Region: _______Zone________ Wereda ________ Kebele ___________________________

Altitude (masl) ____

II. Demographic characteristics and farming system characteristics

1. Name of farm owner: ____

2. Age of farm owner: ____

3. Sex of farm owner: ____

4. Educational status: 1 Basic education (e.g. Religion based) 2. Primary (1 - 6) 4. Secondary (7 - 12) 5. Above Secondary

5. Family size: ____

6. Livestock herd size and composition

Livestock species	Herd size	Trend in the last ten years (Increase or decrease)	Reason for the change in the trend
Cattle			
Sheep			
Goats			
Donkey			
Horse			
Mule			
Camel			
Poultry			

7. Cattle herd size and composition

Cattle type	Status	Number			
		Indigenous	Crossbred	Exotic	Total
Cows	Pregnant non-lactating				
	Lactating non-pregnant				
	Lactating pregnant				
	Dry pregnant				
	Dry non-pregnant				
Heifers					
Bulls					
Male calves					
Female calves					
Steers					
Total					

8. What are the objectives of cattle keeping?

1) Milk 2) Meat 3) Draught 4) Other (s): ________________________________

9. When did you start keeping dairy cattle in your farm?

Breed of dairy cattle % of exotic blood	Year of establishment

10. How do you house your dairy cattle? 1) Separately in corral 2) Mixed in corral 3) Mixed in barn 4) Separately in barn 5) in the farmer's house mixed with people

6) Other (specify) ____

11. What is the type of the farming system in your area/farm? 1) crop-livestock mixed farming

2)crop production 3) Livestock production

12. What are the major crops cultivated in your farm? Rank in their order of importance 1) barley__2) wheat___3) faba bean__4) fieldpea___5) mustard___6) Teff__7) maize___

13. What are the major cattle health problems in the area? List in the order of importance

1) ________2) __________3) __________4) ___________5) _________6___________

14. What is your main source of in come? List in the order of importance

15. What are the types of livestock development services (production or health or credit scheme or other) you get form GO's and NGO's? Please specify the source.

1) ___________2) ___________3 ____________4) ____________5) ______________

16. What are the major constraints of dairy cattle production in your area? List in the order of importance

III. Feed resources and feeding system

1. What are the feed resources available to dairy cattle in your area/farm? List them in the order of their importance.

2. Which type of feeding system are you using? 1) Only grazing, 2) Grazing and stall-feeding, 3) Only stall-feeding

3. If you are using stall-feeding, what are the feed items you supply to dairy cattle in your farm?

4. Do you face seasonal shortage of feedstuffs in your area? 1) Yes 2) No

If yes, specify the season when and the reason why the shortage occurs.

Feedstuff	Season shortage occurs	Reason

5. What other constraints are you facing in feeding your dairy cattle?

List in the order of importance

6. If you are making hay, where do you harvest the pasture for haymaking?

7. If you are using crop residues, what are the most important crops from which you get the residues? Please, list them in the order of importance.

1) barley rank__ 2) wheat rank__ 3)teff rank___ 4)faba bean rank__ 5)Linseed rank__ 6)field pea rank__ 7)others specify____

8. What are the reasons to your preference in ranking the crop residue types?

1) Availability 2) Nutritional quality

9. How do you store crop residues used for feeding cattle in your farm?1) stacked in open air for____months 2)stacked in stall for____months 3)baled for____months

10. What are the most important crops harvested in your farm? Please indicate also the proportion of land allocated for each crop type?

Crop type	Proportion of land allocated (ha)	Yield in quintal
Barley		
Wheat		
Teff		
Linseed		
Mustard		
Faba bean		
Field pea		
Oat		
Others		

11. Do you apply any sort of treatment before you supply crop residues to your cattle? If yes, please, specify the type____

12. Do you allow your animals to feed on crop aftermath? 1) Yes 2) No

13. If yes, in which months of the year can you feed your animal's crop aftermath? __________________________________

14. If you are using concentrates and other supplemental feeds to diary cattle, please specify the types, source and the quantity you acquire per year?

Type of concentrate/supplemental feed	Quantity available per year	Source

IV Land holding and management of grazing land

1. Land holding and use pattern

Land use	Private (own) (ha)	Communal (ha)	Contracted (ha)
Crop land			
Fallow land			
Grazing land			
Others (specify)			
Total land holding			

2. Types of grazing land and ownership (indicate the area in ha)

Types	Private (ha)	Communal (ha)	Contracted (ha)
Drained			
Water logged			
Total			

3. Which animal is/are given priority to graze?

Types of livestock	Rank	Private	Contracted	Communal
Lactating cow				
Dry cow				
Pregnant cow				
Non-pregnant cow				
Heifers				
Breeding bulls				
Traction oxen				
Sheep				
Goats				
Equine				
Others (specify)				

4. Is there grouping of animals during grazing? 1) Yes 2) No if yes, how is the grouping done and why? ____

5. If you have a grazing land, how do you manage the utilization of the grazing land?

Grazing management	Dry season	Wet season
Un-herded		
Herded		
Paddock system		
Other system		

6. Do you cut the pasture and forage on your pastureland? 1) Yes 2) No If yes, when and how? ____

7. If yes, what do you do with the harvested pasture and forage? 1) Feed as green, 2) conserved in the form of hay 3) other uses__________________________________

8. Do you apply fertilizers on your grazing land? 1) yes2) No If yes, which type of fertilizers?

9. Have you ever saw or planted improved varieties of pasture and forage plants? 1) Yes 2) No if yes, specify the name of the plant and the source.

10. What happened to the size of your grazing land in the last five years? 1) Decreasing, 2) increasing, 3) remains constant and why? ______________________________________

11. Do you grow any forage trees? 1) Yes 2) No, if yes, which forage crops and when have you introduced the forage trees? Please specify the number and types of trees per household____

12. Do you grow any forage legumes? 1) Yes 2) No If yes, which forage legumes and when have you introduced the forage legumes? Please specify the size of land on which legumes are grown and types of legumes available in the household.

V. Dairy cattle feeding practices

1. Specify the type and quantity of feed you supply for each group of cattle.

2. If you offer concentrate to milking cows what is your bases for that?

	Quantity supplied per day per animal								
		Concentrates (Specify the type)		Crop residues (specify the types)					
Cattle type	Hay	Lin seed	Wheat bran	barley	wheat	Faba bean	field pea	Lin seed	teff
Lactating cow									
Non-lactating cow									
Pregnant cow									
Non-pregnant cow									
Heifers									
Weaned male calves									
Weaned female calves									
Oxen									
Breeding bulls									

3. If you are offering forage legumes to your cattle, to which group is priority given and how much and how frequent do you supply the feedstuff?

4. If you are allowing your cattle to graze, for how long do they graze? If there is variation between the different groups of cattle in this regard please specify.

5. If you are using cut and carry system, which feedstuff do you cut (grass, legume, crop-stems, or others) and which groups of cattle are supplied with this feedstuff? Please, try to also to quantify the quantity of green feed harvested per day?

6. What are the sources of water for your cows? And how frequent do you supply water to your cattle?

Wet season	source	Watering frequency	Dry season	source	Watering frequency

7. If you do not have farm water, are dairy cattle expected to travel to the source of water, if yes, how long do they travel to get water?

VI. Calf feeding

1. Do you allow the calves to suckle? 1) Yes 2) No, If yes, for how long per day?

2. If you do not allow the calves to suckle, how do you feed milk to your calves? Please specify also the quantity of milk supplied per day per calf? ___________________________

4. At what age do you wean your calves? And what are your bases to wean calves?

5. When do you start to feed your calves with feedstuffs other than milk? ______________

4. Waste management specifically the use of dung? _________________________________

VI. Production performance of herd

1. What is the amount of milk you get per day per cow at three stages of lactation? For how long do you milk your cows?

Cow ID	Breed type	Daily milk yield at three stages of lactation			Average yield/day	Lactation length
		Beginning	Middle	End		

2. When did your cows gave birth to their first calf?

Cow ID	Breed Type	Age at first calving

3. When did your calves gave birth recently and immediately before the recent calf?

Cow ID	Breed Type	Recent calving date/month	Previous calving date/month	Calving I

4. How many timed did you take your cows for service for the last conception/pregnancy?

Cow ID	Breed Type	Number of services per conception

Annex 2 Analytical procedures

1. Ash

Weigh 2 g of sample into a crucible and place in temperature controlled furnace heated to 6000C for 2 hours. Transfer crucible directly to desiccators, cool and weigh immediately reporting % ash to first decimal.

2. Crude protein Kjeldahl method

Weigh 0.7-2.2 g of (ground) samples in kjeldahl digestion flasks, 500 ml-800ml capacities. Add 10 g of mixture of CuSO4 and powdered potassium Sulphate (1:5 ratio) or 2 kjeldahl tablets (called Kjeltabs) and 25 ml of sulphuric acid. (If sample is greater than 2.2 g increase H_2SO_4 by 10 ml for each g of sample).

Place flask in inclined position and heat gently until frothing ceases. Boil briskly until solution clears and then for about 30 minutes longer. Allow to cool, and 250 ml of distilled water and the 90 ml of 40% NaOH solution without agitation. Immediately, connect flask to distilling bulb on condenser immersed in standard acid and 5-7 drops of indicator (or mixed indicator /boric acid solution) in receiver. Rotate flask to mix contents thoroughly then heat until all NH_3 has been distilled (until approximately 150 ml of distillate has been obtained). Remove receiver, wash tips of the condenser with a little distilled water and titrate excess standard acid in distillate with a standard NaOH solution. (If you use mixed indicator/boric acid solution titrate distillate against std. acid solution).

3. Detergent Fiber

3.1. Neutral Detergent Fiber (NDF)

Weigh l g of sample ground to pass through l mm screen. Place in 600 ml refluxing beaker, add 100 ml Neutral detergent Solution (NDS), 2 ml decalin, about 0.5 g of sodium Sulphite (use calibrated scoop and heat to boiling). Filter contents in to previously weighed Gooch crucible of coarse porosity (porosity 1) using light suction Break up filtered mat; wash with in nearly boiling water at 100^0C overnight and weight.

3.2. Acid Detergent Fiber(ADF)

Weigh 1g air-dried sample ground to pass through 1mm screen. Place in 600ml refluxing beaker; add 100ml of ADS and heat to boiling (if foaming can not be controlled add 2ml of Decalin).filter concentrate in to previously weighed Gooch crucibles of coarse porosity (porosity 1) using light suction. Break up filtered mat, wash with acetone. Suck the crucible free liquid, dry at 100^0C overnight and weight

4. In vitro digestibility: Two stage technique of Tilley and Terry

1. Transfer in to 120 ml plastic centrifuge tubes in qua-ruplicate a weighed amount of air dry sample of feed that would be approximately 0.5 g oven dry
2. In each run include four tubes with no substrate as blanks. Also include four tubes of sample of known in-vitro digestibility, or one that has had its in-vitro digestibility determined several times.
3. Weigh out 1.0 g of feed sample in duplicate in to porcelin crucibles, and determine the dry matter content and the organic matter (100-ash%DM) if OMD is being determined.
4. Warm the phosphate- bicarbonate buffer over the weakened (39^0C) in water bath.

5.Calcium(Ca) and phosphorous(P) analysis was done after preparing sample by the wet digestion method using Sulphuric acid in the presence of hydrogen peroxide (Cottenie,1980).

Annex 3 Table 1 TLU conversion factors for different Livestock species

Types of Animals	Indigenous bred		Cross bred	
	Live weight	TLU	Live weight	TLU
Cows	250	1.00	380	1.5
Heifers	125	0.5	150	0.6
Ox/young bulls	250	1	300	1.2
Calves	50	0.2	50	0.2
Sheep and goats	22	0.1		
Horse and mules	200	0.8		
Donkeys	90	0.4		

Source: (Varviko, 1991)

Annex 4 Table 2 Conversion factor for fallow land, crop after math, and woods, bushes and shrubs

Types of land use	Dry matter yield/ha/year(tons)
Fallow Land grazing	1.8
Crop after math	0.5
Wood, bush, and shrub land	1.2

Source: FAO (1987)

Annex 5 Table 3 conversion factor for different crop residues

Wheat	1.5
Barley	1.5
Teff	1.5
Oats	1.5
Faba bean	1.2
Field pea	1.2
Lentils	1.2
Linseed	1.2
Maize	2.0
Sorghum	2.5
Chick pea	1.2

Source: FAO (1987), Ahmed (2006)

Annex 6Table 4 Estimation of the DM available in natural pasture in different seasons

Seasons	Pasture condition	area (ha)	DM yield/ha (tons)	Forage production (tons)	Sources
Main rainy season	Relatively drained	241.5	3.6	869.4	Current study
	Seasonally water logged	287.25	3.65	1048.48	Current study
Main rainy season	Relatively drained	206.25	2.47	509.44	Terefe(2007)
	Seasonally water logged	114.3	4.4	502.9	Terefe(2007)
Dry season	Relatively drained	206.25	0.65	134	Bayisa(2004)
	Seasonally water logged	114.3	0.5	57.2	Bayisa(2004)
short rainy season	Relatively drained	206.25	0.16	33	Bayisa(2004
	Seasonally water logged	114.3	0.39	44.6	Bayisa(2004
Total		1490.4		3199	

8 BIOGRAPHICAL SKETCHES

The author was born in 1963 in Almeda kebele, Adwa Awraja, Tigray National Regional state. Completed his elementary and secondary school education at Betekihnet and Queen Sheba Secondary School in Adwa town, and joined Alemaya University in 1987. The author was awarded BSC in Animal Science in December 1991. After his graduation, joined the Ministry of Labour and Social affair and worked as Forage Development Expert, Livestock and livestock products division head and Agricultural development department head respectively up to Feb. 10/2002 in Ethiopia Children Amba which later became Alage Rehabilitation center for the disable and then Alage ATVET College, transferred to Agarfa Agricultural Technical Vocational and Educational Training (ATVET) College which is found in Oromia National Regional state, Bale Administrative Zone in Agarfa Wereda From Feb.11/2002-Dec. 02 serving as Agricultural & Cottage Industry Coordination Office head. In Dec. 03/2002, again transferred to Bekoji ATVET College being Academic Vice Dean and works till his graduation. In June 2005 He joined the graduate program in Tropical Animal Health and Production at Addis Ababa University Faculty of Veterinary Medicine Debrezeit.

9. DECLARATION SHEET

I, the under signed solemnly declare that this thesis is my original work and is not submitted to any other institution anywhere for the award of any academic degree, diploma, or certificate. All sources of materials used for this thesis have been duly acknowledged.

Name: Teklay Asgedom Teferi   Signature: ……………………...............

Place: Faculty of Veterinary Medicine, Debrezeit-Ethiopia

Date of Submission: June 24/2008

Academic advisors

Name	Signature
1. Dr. KELAY BELIHU ADVISOR (PhD)	___________
2. Dr. BERHAN TAMIRCO -ADVISOR (PhD)	___________