ASSESSMENT OF LIVESTOCK FEED RESOURCES AND EVALUATION OF THEIR NUTRITIOAL QUALITIES IN LALO KILE DISTRICT OF KELLEM WOLLEGA ZONE, WESTERN ETHIOPIA

MSc Thesis

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JIMMA UNIVERSITY

November, 2015

JIMMA ETHIOPIA

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By

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Thesis Submitted to the School of Graduate Studies,
Jimma University College of Agriculture and Veterinary Medicine,
Department of Animal Science

Jimma Ethiopia

In Partial Fulfillment of the Requirements
For the Degree of Master of Science in Animal Sciences
(Specialization: Animal Production)

November, 2015
JIMMA ETHIOPIA

SCHOOL OF GRADUATE STUDIES

JIMMA UNIVERSITY

COLLEGE OF AGRICULTURE AND VETERINARY MEDICINE

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We, the undersigned, member of the Board of Examiners of the final open defense by **Jabesa Ayele Hika** have read and evaluated his/her thesis entitled "**Assessment of Livestock Feed Resources and Evaluation of Their Nutritional Qualities in Lalo Kile District of Kellem Wollega Zone, Western Ethiopia."** and examined the candidate. This is therefore to certify that the thesis has been accepted in partial fulfillment of requirements for the degree Master of Science in **Animal Production.**

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DEDICATION

This thesis is dedicated to my beloved mother W/ro Alamitu Dureso Hora, who passed away and for her love, proper guidance and support contributed a lot in my career and day to day life. I deeply wish that God would give her peaceful rest forever.

STATEMENT OF AUTHOR

I the undersigned, hereby declare that the thesis: Assessment of Livestock Feed Resources and Evaluation of their Nutritional Qualities in Lalo Kile District of Kellem Wollega Zone, Western Ethiopia is the outcome of my own work and all sources of materials used have been duly acknowledged. This thesis has been submitted in partial fulfillment of the requirements for MSc degree at Jimma University and is deposited at the University Library to be available to borrowers under rules of the library. I solemnly declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree. I concede copyright of the thesis in favor of the Jimma University, Collage of Agriculture and Veterinary Medicine.

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BIOGRAPHICAL SKETCH

Jabesa Ayele Hika, the author was born on January 1, 1987G.C. in Saggo kebele, Kellem Wollega Zone, Oromia Region. He attended his elementary education at Denta School in 1994 -1999G.C. and his junior secondary education at Lalo junior secondary School in 2000-2001G.C.He completed his secondary education at Alemtefery senior secondary school in 2002-2005G.C. Then he joined Jimma University in 2006 and graduated with BSc degree in Animal science on 14th June, 2008. After graduation he served in Yubdo district of Livestock development and health care Agency until he joined Jimma University, School of Graduate studies for the Degree Master of Science in Animal production in 2013 G.C.

ACKNOWLEDGMENT

At the outset, I would like to praise the everlasting Father and the Prince of love and peace the Almighty God who always let the bulk of unfinished work to be completed at a moment.

I am grateful to my respected major advisor Taye Tolamariam (PhD), for his unreserved advice, guidance and constructive criticism. Without his encouragement, insight and professional expertise, the completion of this work would not have been possible. My thanks also go to my co-advisor Abegaz Bayene (PhD) for his valuable comments on my research work starting from the very commencement up to thesis completion.

I would like to thank the Yubdo district administration, and Livestock development and health care agency for the institutional support to get this opportunity. I also wish to express my heartfelt thanks to the all farmers who responded to my numerous questions with patience. My special thanks also to the Animal Science Department of Jimma University, the staff of nutrition laboratory for their assistance given to me during laboratory work.

My special thanks and heartfelt gratitude extends to my brother Charinet Ayele and Mosisa Betiro for their patience, support and encouragement. I also thank all people who assisted me in one way or another during my study period.

LIST OF ABBREVIATIONS

ADF	Acid Detergent Fiber
ADO	Agricultural District Office
AOAC	Association of Official Analytical Chemists
^0C	Degree Celsius
CF	Crude Fiber
CGL	Communal Grazing Land
CP	Crude Protein
CSA	Central Statistical Agency
CV	Coefficient of Variance
DCP	Digestible Crude Protein
DM	Dry Matter
EE	Ether Extract
ELDMPS	Ethiopian Livestock Development Master Plan Study
FAO	Food and Agricultural Organization
gm	Gram
H_2SO_4	Sulpheric acid
h	Hours
kg	kilogram
km	kilometer
LDHAD	Livestock Development and Health care Agency of the District
L/AU	Liter per Animal Unit
m	Meter
mm	Millimeter
ME	Metabolizable Energy
MJ/kg	Mega Joule per kilogram

LIST OF ABBREVIATION (*continued*)

m.a.s.l	Meter Above Sea Level
N	Nitrogen
Na_2SO_3	Sodium sulphate
NDF	Neutral Detergent Fiber
NRC	National Research Council
OM	Organic Matter
PGL	Private Grazing Land
SAS	Statistical Analysis of System Software
SNV	Netherlands Development Organization
SPSS	Statistical Package for the Social Sciences
TDM	Total Dry Matter
TLU	Tropical Livestock Unit
TME	Total Metabolizable Energy
t/ha	Tons per hectare
WIIAL	Winrock International Institute for Agricultural Development

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ASSESSMENT OF LIVESTOCK FEED RESOURCES AND EVALUATION OF THEIR NUTRITIOAL QUALITIES IN LALO KILE DISTRICT OF KELLEM WOLLEGA ZONE, WESTERN ETHIOPIA

ABSTRACT

This study was conducted to assess the livestock feed resources and evaluation of their nutritional qualities in Lalo kile district of Kellem Wollega zone, western Ethiopia in terms of quantity and quality, evaluating feeding system, determining the balance of feed resources supply and livestock requirements, and identify constraints and opportunities of livestock production in relation to availability of feeds. Stratified random and purposive sampling techniques were used to select the kebele and target households. The district was stratified in to two agro ecologies, mid and low altitude areas. A total 127 households, 66 from three mid altitude kebeles namely (A/kucho (30), F/jirru (16) and Seggo (20)) and 61 from three low altitude Kebeles (H/abote (20), M/kallisa (14) and Wabera (27)) were selected for interview. Structured questionnaire, secondary data sources and field observations were employed to generate the qualitative data; while laboratory chemical analysis was used to get the quantitative data. The surveyed data were analyzed using GLM ANOVA procedures for social sciences (SPSS, version 20). The result of the study indicated that natural pastures (36%), crop residues (34.49%), fodder trees and shrubs (15.60%), stubble crops (8.13%), non-conventional feed (4.46%) and others were the proportion of major available feeds resources with varied in agro ecologies. About 73.13% of grasses, 15.32% of legumes and 11.55% of herbaceous were the species biomass composition. The average biomass yields of fodder trees and shrubs were 7.98-19.78kg/ tree and 1.06- 2.41kg/shrub in mid altitude and 9.87-178.06kg/tree and 1.34-3.87kg/shrub in low altitude area. The total biomass dry matter yield of fodder shrubs and trees was estimated 74.36-100kg/ha and 500-800kg/ha from cultivated and uncultivated land in study area, respectively. The average annual dry matter production from natural pasture, crop residues, fodder trees and shrubs, stubble crops, non-conventional feed and improved forages were 4.3±0.13, 4.1±0.11, 1.83±0.01, 0.96±0.03, 0.52±0.004 and 0.15±0.03tons/household/year, respectively. In the dry season most of available feed resources were poor in nutritional qualities with significant differences in agro ecologies ($p<0.05$) and strategic supplementation of protein and energy rich feeds like fodder trees should be required. The feed supply in terms of DM, ME and DCP was 11.87± 0.56tons, 74,781MJ/kg and 118.61kg per household per year, respectively. The feed balance was found to be negative and significant difference across the study areas ($p<0.01$).The overall annual feed supply on a year round base meets only 66.13, 25.81 and 87.24% of the DM, DCP and ME total requirements per household, respectively. Alternative means of dry season feed production and supply should be in place with the involvement of all stakeholders and development actors.

Key words: *Feeds, Feed supply and requirements, Feeding system, and Chemical composition and nutritive values of feeds, Lalo kile.*

1. INTRODUCTION

Ethiopia holds a substantial potential of livestock population with diversified agro ecologies, currently estimated at about 53.99 million cattle, 25.49 million sheep, 24.06 million goats, 1.91 million horses, 6.75 million donkeys, 0.35 million mules, 0.92 million camels, 50.38 million poultry and 5.21 million beehives (CSA, 2013). Livestock rearing is practiced in almost all parts of the country across all agro-ecological set up. However, the productivity of the livestock resources and the benefits obtained from the sector does not proportionate with the high livestock population due to various constraints that include poor nutrition, poor genetic makeup local animals and disease prevalence (Asfaw *et al*., 2011). Among these constraints issues related to feed are the most severe ones. The limited feed supply and poor qualities of the available feeds are the major constraints for optimal livestock productivity in tropical and sub-tropical countries (Solomon *et al.*, 2010; Boufennara *et al.*, 2012).

Livestock feeds are obtained from natural pasture, crop residue, agro industrial by products and other by-products like food and vegetable refusal, and to some degree, improved pasture and forage species in Ethiopia (Alemayehu, 2003). Particularly in mixed crop-livestock production systems of the Ethiopian highlands, feed resources for livestock mainly come from marginal pasturelands, crop residues and aftermath grazing (Solomon *et al*., 2008; Bayush *et al*., 2008). However, these feed resources are inadequate quantitatively, seasonal fluctuation and poor in qualitatively to support livestock production (Mohamed-Saleem and Abate, 1995). An excessive supply of feed during the rainy season is usually followed by a deficit in grazing in the following dry season (Alemayehu, 1998). According to ELDMPS (2007), even during normal years there is a deficit of 35% in feed supply and this figure rises to 70% during drought years.

Natural pasture constitutes the major source of basal feed for livestock in the central highlands of Ethiopia. However, the progressive decline of average farm sizes in response to rising human populations, encroachment of cropping land onto erstwhile grazing areas and onto less fertile and more easily erodible lands, and expansion of degraded lands, which can no longer support either annual crops and pastures that contributes to shortage of feed resources (Alemayehu, 2005). Poor grazing management has resulted in very low carrying capacities brought about replacement of productive and nutritious flora by unpalatable species and reduction in vegetation cover with a consequent poor carrying capacity (Ahmed, 2006). This stretches pasture capacity beyond its limits; consequently decreasing pasture quality results in low livestock production performance (SNV, 2008). It is also characterized by seasonal fluctuation in total dry matter (DM) production and nutritional quality because of the distinct seasonal variation in plant growth, in relation to the annual rainfall pattern.

Crop residues are the other major feed resources, particularly during the dry season. However; the availability of crop residues is closely related to the farming system, the type of crops produced and intensity of cultivation. The utilization efficiency and post harvest loss had great problems to the available feed resources especially for crop residues (Yeshitila, 2008). Crop residues are also fibrous and high in lignin content, which limit the feeding value (McDonald *et al*., 2002; Adugna, 2009) and low content of essential nutrients (proteins, energy, minerals and vitamins) leading to low digestibility and intake. They hardly fulfill even the maintenance requirements of animals for essential nutrients (Steinbach, 1997).

Feed quality can be measured by the potential to produce a desired animal response. Thus, the quality reveals the level of nutrient (chemical) composition, palatability and intake, digestibility, anti-nutritional factors and animal production performance (Abeysekara, 2003). Availability of feed containing imbalanced chemical composition and metabolizable energy (ME) is major handicap in ruminant production the world over (Niderkorn & Baumonta, 2009). Most of the chemical composition of feedstuffs obtained from natural pasture and crop residues have crude protein (CP) levels below 8% and neutral detergent fiber (NDF) of above 55% (Seyoum and Zinash 1995).

In this respect, Lalo kile district is not exceptional and the same trend was observed due to prioritizing better lands for cultivation results to compete grazing lands. According to the livestock development and health care agency of the district (2015), the total livestock population of the district is about 190,439 which are quite considerable to poverty eradication and food security and that will be achieved only, if feed problem is resolved. To this effect, comprehensive survey of the types, quantity, quality, availability, alternative uses and relative costs of the different feed resources is important to identify the feed resources and to facilitate the decision making process in livestock feed resource development under small holder conditions.

Most of the research works assessed on feed resources in different parts of the country so far conducted only indicated the shortage of feeds without quantifying the amount of dry matter (DM), metabolizable energy (ME) and digestible crude protein (DCP) basis obtained in each feed resource type and whether this is adequate to the total number of livestock available to that particular area. This shows further study is required a possible solution to livestock producers particularly in the extreme dry seasons in Ethiopia. The information on nutritional characterization of locally available feed resources at country level is also inadequate and where the available values are variably documented (Zinash and Seyoum, 1998). The estimate on carrying capacity based on forage quality and nutritive values are also scant in the country. The great diversity and nutritional values of feeds in the stud district in particular have not yet been investigated. Therefore, the main purpose of this study is to generate base-line information on livestock feed resources, the existing feeding system, and evaluate the efficiency of feed resource utilization as well as constraints and opportunities of livestock production in relation to feed resources availability in the study area. The specific objectives of the study were to:

- assess feed resources availability in terms of quantity and quality;
- evaluate the livestock feeding systems;
- determine the balance of feed resources supply and livestock nutrient requirements and
- Identify constraints and opportunities of livestock production in relation to available feeds in the study area.

2. LITERATURE REVIEW

This section reviews the relevant literatures on potential available livestock feed resources in terms of types, quantity of biomass yield and total dry matter production and feed qualities in Ethiopia. It also reviewed how the livestock feeding systems are carried out.

2.1. Potential Feed Resources Available in Ethiopia

Livestock feed resources in Ethiopia are mainly natural grazing lands and browses, crop residues, forage crops and agro-industrial by products and other by-products like food and vegetable refusal, stubble grazing and browse species which are used at the site of production or conserved for use during seasons of shortage. Shitahun (2009); Dawit *et al.* (2013) and Bisrat(2014) reported that natural pasture, weeds, aftermath grazing, crop residues and maize thinning in wet season and crop residues, aftermath grazing, hay and supplements were the major feed resources in dry season. Their contribution to the total feed resource base varies from area to area based on cropping intensity (Seyoum *et al*., 2001). At present, livestock are fed almost entirely on natural pasture and crop-residues. Using of improved forages and agro-industrial by products is minimal and most of agro industrial by-products are concentrated in urban and peri-urban areas (Alemayehu, 2005). Though increased utilization of agro-industrial by-products has been reported (Benin *et al.*, 2004), they are not available, affordable or feasible for most of the farmers in Ethiopia.

Depending on agro-ecology, different feeds are available at different season of the year. In the low altitude of rangeland areas, grazing/browsing serves as the main source of feed available for most part of the year. While in the mid-altitude and highland areas, crop residues, stubble grazing, harvested hay, grazing/browsing, and to limited extent improved forages constitute the major feeds for livestock (Yayneshet, 2010).

2.1.1. Natural Pastures

Natural pasture refers to naturally occurring grasses, legumes, forbs, shrubs, and tree foliages used as livestock feed (Fekede *et al.*, 2011). The availability and quality of natural pastures vary with altitude, rainfall, soil type and cropping intensity (Adugna, 2008). In Ethiopia the feed from natural pastures is estimated to covers 80-90% of the livestock feed (Alemayehu, 2006) and varies between the lowland and highland parts of Ethiopia. Despite the continued expansion of croplands into the grasslands and the resultant decline in the size of grazing areas, native pastures remain the major contributors of livestock feed in the densely populated highlands of Ethiopia (Lemma *et al.*, 2002). According to FAO (2001), grazing lands still play a significant role in livestock feeding and support a diverse range of grasses, legumes, shrubs and trees.

In the highlands of Ethiopia, seasonal fluctuation in the availability and quality of natural pasture is a common phenomenon which results in serious feed shortage thereby affecting livestock production and productivity (Solomon, 2004). Grazing of pasture and rangelands is an integral component of livestock production systems in many countries (Johansson *et al*., 1996). Livestock grazing stimulates nutrient mobilization and uptake through consumption of vegetation; in that mobilization of nutrients to the growing points is enhanced by frequent defoliation (Mohamed *et al.*, 1998).

Natural grassland consists of the main highlands pastures of Ethiopia and accounts for about 30.5% of the area of the country (Alemayehu, 2004). The size of the grazing land is decreasing over time with the expansion in farmland size, which is a result of the increase in human population. The size of the grazing land has declined after the land redistribution because of the decrease in the size of land holdings. Accordingly, the feed obtained from grazing lands is inadequate both in terms of quantity and quality throughout the year (Ahmed *et al*., 2010). Natural pasture grazing lands are divided into private and communal grazing lands. Grazing on either private grazing land (PGL) or communal grazing land (CGL) is a common practice following the onset of rain in most parts the country (Ahmed *et al*., 2010).

2.1.2. Crop Residues and Stubble Grazing

Among the constraints facing livestock production in developing countries, inadequate animal nutrition and productivity arising from inadequate feed supplies stands as the most important (Yayneshet, 2010). Crop residues are the fibrous parts of crops that remain after the parts edible by human beings are removed. These feed resources are used as livestock feeds since time immemorial. In arid and semi-arid tropics where natural pastures are only seasonally available because of the shortage of moisture, crop residues assume great importance in decreasing the level of feed deficit. Depending on the type of crop, crop residues may be left on the field either as grazing for ruminants or as mulch, or they may be transported to the homestead for stall feeding or other alternative uses such as fencing, building and roofing materials or as fuel (Tesfaye and Chairatanayuth, 2007).

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 residue is closely related to the intensity of crop farming. Therefore, in integrated crop/livestock systems the potential of using crop residue as feed for livestock are greatest (Alemayehu, 2005).

In the mixed cereal livestock farming systems of the Ethiopian highlands, crop residues provide on average about 50% of the total feed source for ruminant livestock. The contributions of crop residues reach up to 80% during the dry seasons of the year (Adugna, 2007). Further increased dependence on crop residues for livestock feed is expected, as more and more of the native grasslands are cultivated to satisfy the grain needs of the rapidly increasing human population. In spite of the rising dependence on fibrous crop residues as livestock feeds, there are still certain constraints to their efficient utilization and post harvest handling. Substantial efforts have been made so far to resolve the feed shortage problem in Ethiopia, aiming at improving feed availability and thereby improve livestock productivity. However, the impact was so little to cope with the problem that animals are still subjected to long periods of nutritional stress (LDMPS, 2006).

The ways of storages, length and forms of feeding of crop residues are varies from place to place. Tesfaye (2006) reported almost all the farmers collect and then store all their teff, wheat and barley straws in open air (without shelter) to use it later in the year. Endale (2015) reported that the 17.8% of respondents were providing crop residues two months after collection in Meta Robi district. In contrastingly Zewdie (2010) reported about 88% of the respondents provide crop residue soon after collection in the highland production system. Endale (2015) also reported that feeding crop residues in whole (72.2%), chopped (16.7%), treated straw (3.3%) and mixed with other feeds (7.8%) was practiced at Metta robi district.

Stubble crops are one of the important feed sources in Ethiopia. After harvesting the crops, livestock are allowed to graze stubble of different crops (maize, sorghum, barley, wheat, teff, and oats) mainly from October to December (Beyene *et al*., 2011). For the first two months, the stubble is grazed by the animals of the farm owner and later it becomes accessible to all animals in the community (Ahmed et *al*., 2010). The CP content of stubble crops was found to be lower than that of straw. This was attributed to the low leaf to stem ratio of stubble crops (Solomon, 2004).

2.1.3. Agro-industrial By-products

The supplementation with energy and protein-rich concentrates of forages which are likely to be of low nutritional value, can be expected to improve dry matter intake, milk yield, milk solids content, body condition, nutrient utilization efficiency of livestock and most probably will result in a favorable benefit-cost ratio (Rehrahe *et al*., 2003; Tadesse *et al*., 2003 and Meeske *et al.*, 2006). Supplemental feeds such as the by-products of grain and oil seed mills are fed to livestock especially when there is shortage of feed. Farmers in high altitude zone, especially those around the peri-urban areas, utilize by-products of grain for lactating crossbred cows. By- products of oil seeds secured through purchase from the local market are mixed with straw and other local supplements such as the spent brewer's grains from the local manufacture of "*atela*" to feed livestock especially cross-bred dairy cows (Ahmed *et al*., 2010).

Agro-industrial by-products have special value in feeding livestock mainly in urban and peri-urban livestock production system, as well as in situations where the productive potential of the animals is relatively high and require high nutrient supply. The major agro-industrial by-products commonly used are obtained from milling industries, edible oil extracting by-products, brewery and sugar producing industries (Adugna, 2007 and Birhanu *et al*., 2009). Though increased utilization of agro-industrial by-products has been reported (Benin *et al*., 2004), they are not available, affordable or feasible for most of the farmers in the highlands of Ethiopia. Under smallholder livestock production system, animals are dependent on a variety of feed resources which vary both in quantity and quality.

The various milling by-products obtained through processing wheat bran, corn and barley are of great interest as livestock feed for state farms, city dairy holders and to a lesser extent for some dairy co-operatives. Wheat grain is processed in big mills, whereas in the case of teff, barley, maize and sorghum the whole grains are processed and used for food (Yayneshet, 2010).

Oil cakes are an excellent concentrate feed for ruminant livestock in Ethiopia which grows most of the temperate and sub-tropical oilseed plants such as linseed, groundnuts, rape, sesame, sunflower, cotton seed and noug cake. The processing factory of oilseeds is widely practiced on a family basis or in small village mills. Brewer's grains are traditionally valued for lactating cows because of their palatability and milk-producing property. In addition to traditional brewing production there are more than nine breweries are practiced in the country (Yayneshet, 2010).

2.1.4. Fodder Trees and Cultivated Forages

Fodder trees are the leaves, pods of trees and shrubs and twigs growing on shrubs, woody vines and trees available for animal consumption (Alemayehu, 2006). Foliage of trees such as different acacia species and *Balanites aegyptiaca* as well as the pods and fruits of trees/shrubs can be used as substitute for concentrate supplement. Fodder trees and shrubs are important animal feeds in Ethiopia especially in arid, semi-arid and mountains zones, where large number of the country`s livestock are found (Alemayehu, 2004). Babayemi and Bamikole

(2006) opined that fodder and shrubs are important components of ruminant diet and they have been found to play important roles in the nutrition of grazing animals in areas where few or no alternatives are available. Browses have multiple roles in farming systems such as feed, fuel wood and as human and veterinary medicines (Luseba and Van der Merwe, 2006). Their importance increases in arid areas (Getachew, 2002). The importance and availability of trees and shrubs in tropical Africa are influenced by the distribution, type and importance of livestock, their integration and role within the farming systems and availability of alternative sources of feed (Getachew, 2002).

The potential available resources of fodder trees and shrubs in different areas reported by the number of authors (Abebe *et al.*, 2008; Belete *et al.*, 2012; Diriba *et al.*, 2013; Mulugeta and Kindu, 2013 and Takele *et al.*, 2014). The common browse species indentified in Ethiopia are: *Acacia ask, Acacia lahai, Acacia oerfeta, Acacia Senegal, Acacia tortilis, Albizia amera, Balanites aegyptiaca, Boswellia papyrifera, Ficus glumosa, Ziziphus spina-christi, Acalypha fruticosa, Xanthum spinosa, Ziziphis Mauritania* (Teferi, 2006 and Adugna, 2007).

Production of cultivated forage and pastures depends on availability of species that are adapted to the climatic, edaphic and biotic factors prevailing in the environment in which they are to be utilized. Suitability of a forage species to a given area is judged based on dry matter yield potential, persistence, adequate feed quality, compatibility with other species and ease of propagation and establishment. Cultivated forage and pasture crops are mainly important as cut-and-carry sources of feed and as a supplement to crop residues and natural pastures. The type of cultivated forage crop produced is variable from place to place depending upon the prevailing climatic and edaphic factors. The most common cultivated forage crops include grasses like elephant grass (*Pennisetum purpureum*), Rhodes grass (*Chloris gayana*), guinea grass (*Panicum maximum*) and oats (*Avena sativa*) in the highlands. Among the herbaceous legumes, the most common ones include desmodiums (*Desmodium* spp.), vetch (*Vicia* spp.), Lucerne (*Medicago sativa*), lablab (*Lablab purpureus*), cowpeas (*Vigna unguiculata*) while the most common fodder tree legumes include Leucaena (*Leucaena* leucocephala), Sesbania (*Sesbania sesban*), *Calliandra calthyrsus, Gliricidia sepium,* pigeon pea (*Cajanus cajan*) and others. Tagasaste (*Chamaecytisus palmensis*) is important in the highlands (Adugna, 2008).

Most browse species maintain their greenness and nutritive value throughout the dry season when grasses dry up and deteriorate both in quality and quantity. They are generally rich in CP and minerals and they are used as a dry season supplement to poor quality natural pasture and fibrous crop residue (Devendra, 1990). Animals grazing mature grass pasture are often able to supplement their diet by consuming the foliage of trees and shrubs, many of which are legumes. They are high in protein (200-3000g/kg DM) and minerals, but also high in fiber (500-600g/kg neutral detergent fiber) and foliage of some species also has a high concentration of condensed tannins (McDonald *et al.*, 2002).

2.1.5. Other Feed Resources

Livestock feed resources are classified as conventional and non-conventional (Alemayehu, 2003), where the non-conventional ones vary according to the feeding habit of the community and others, e.g. vegetable refusals, sugar cane leaves, Enset leaves, fish offal and etc are non-conventional feed types. Yeshitila (2008) also identified non conventional feeds and it includes like residues of local drinks coffee, *areke*, a*tela, chat* left over called *geraba*, fruits and vegetables reject. Endale (2015) reported utilization of non-conventional feeds other than local alcohol waste (*Atella*) was very low.

2.2. Assessment of Quantities of Feed Resources

Feed is the most important requirements for metabolic activities, maintenance, production, reproduction and gain in body condition of livestock. The supply of feed in both quantity and quality determines productivity and profitability of livestock farms (Sarwar *et al*., 2002). Under smallholder production system animals are dependent on a variety of feed resources, which vary in both quantity and quality. Livestock production in Ethiopia suffers from feed shortages at all levels. It is estimated that there is a 40% deficit in the national feed balance (Fekede *et al.*, 2011). Even during years of good rainy season, forage is not sufficient to feed livestock in the highlands for reasons associated with restricted grazing land and poor management (Melese *et al.*, 2014). This is again aggravated by seasonal availability of forage and crop residues in the highlands and by erratic rainfall in the lowlands. Because of dynamic changes, traditional feed resources and existing feeding management strategies are no longer adequate to sustain a productive livestock population (Benin *et al.*, 2003 and Sarwar *et al.*, 2002).

Seasonal variations and inadequate supply of quantity and quality feed are the major technical factors limiting the productivity of the livestock in Ethiopia. Feed, usually based on fodder and grass is not available in sufficient quantities due to fluctuating weather conditions (Ahmed *et al.,* 2003). Natural pasture supply the bulk of livestock feed which is composed of indigenous forage species and is subjected to overgrazing. The fibrous agricultural residues contributes a major parts of livestock feed especially in the populated countries where land is prioritized for crop cultivation. Adugna *et al*. (2012) reported that crop residues contribute to about 50% the total feed supply in Ethiopia.

The botanical composition of natural pasture is dynamic and varies depending on topography, climate and soil type. Natural pastures in the highlands of Ethiopia are rich in species composition, particularly indigenous grasses and legumes (Adane, 2003; Tessema, 2003 and Yihalem, 2004). Zewdie (2010) reported grasses species represented 86% of the DM biomass production while forage legumes only 2% in Central Rift Valley of Ethiopia. Both productivity and species composition (e.g., grass-legume) impacts the feed quantity and quality and therefore productivity of livestock (Bedasa, 2012).

The productivity of natural pasture is variable depending on soil type and agro-ecological conditions. There are limited studies previously reported on the DM yield of natural pastures in different agro ecologies different dry matter production yields. In central highlands of Ethiopia estimated the annual DM yield of natural pasture to be 4.5 t/ha on seasonally waterlogged bottomlands (Alemayehu, 1987), 3 t/ha for protected grasslands (Jutzi *et al*., 1987) and 6 t/ha for well managed natural pasture (Yihalem, 2004). Bilatu *et al.* (2013) reported the average yield of natural pasture was 5.4 t/ha per one growing season in North West lowland of Ethiopia. The highest dry matter was recorded in Pawe 6.2 t/ha followed by Gublack 5.1 t/ha and the smallest was in Dibate (4.1 t/ha) (Bilatu *et al*., 2013).

The dry matter production of communal and private grazing areas of grasses, legumes and others forbs were 2.84 ± 0.48ton/ha, 0.81 ± 0.14ton/ha, 0.645 ± 0.14 and 6.62 ± 0.52, 0.88 ±

0.14, 0.29 ±0.16 in Metema district of Ethiopia (Tesfaye, 2008). Grazing lands biomass DM yield is very low (e.g., 1.6 ton ha^{-1} in Fogera) (Descheemaeker *et al*., 2010b). Beyene *et al*.(2010) reported that the average dry matter yields of grasses, legumes and others herbs from natural pasture were 1.891tons/ha, 0.399 tons/ha and 0.205 ton/ha in shifting cultivation and 1.251tons/ha, 0.218tons/ha and 0.216tons/ha in permanent farming system ,respectively at Asosa zone, western Ethiopia. Zewdie (2010) also reported with the average dry matter yield from grasses, legumes and other herbs were 1.172t/ha, 0.0127t/ha and 0.048t/ha around Ziway, central rift valley of Ethiopia. Alemayehu and Amaha (2006) reported that overgrazing might have been the main factor for the decline in the composition and diversity of plant species over a long period of time. Soil types also the determinant factors that affect biomass production. The change of species composition in the grassland vegetation naturally depends upon a number of factors. From ecological point of view, grassland develops as a direct expression of the climate and other sets of factors which are unfavorable for the growth of trees including altitude, soil and farming system (Alemayehu, 2004). The ways people use and manage the grazing pasture influences the quality and quantity, as well as seasonal distribution (Thompson, 2007) and also affect the composition of species lead to palatable and nutritious species being replaced by unpalatable species.

The available quantity of each type of crop residues varied from place to place and between species. Shitahun (2009) reported the total utilizable DM production from cropping system per household significantly varied between the agro-ecologies that accounted for 8.05 TDM and 16.36 TDM in mid altitude and low altitude agro ecologies, respectively. Dawit *et al*. (2013) reported total utilizable DM production from cropping system was 10.9±1.1 and 8.5±0.5 TDM per household in rural and peri urban of Adami Tullu Jiddo Kombolcha district, respectively. In addition the dry matter production of stubble crops was also depends on crop production and farming system. Yeshitila (2008) reported the values of stubble crops 1.17± 0.08, 1.56± 0.11 in farming system I and II and an overall value of 1.34 ± 0.71 tones per household in Alaba district, south Ethiopia.

Fodder trees and shrubs are important components of ruminant diet and they have been found to play important roles in the nutrition of grazing animals in areas where few or no alternatives are available (Babayemi and Bamikole, 2006). Browses have also multiple roles in farming systems such as feed, fuel wood and as human and veterinary medicines (Luseba and Van der Merwe, 2006). The biomass yields of fodder trees and shrubs varies from species to species, age of growth and place to place. The variation among species in biomass yield suggests differences in potential biomass yield that may be associated with differences in growth of the species, spatial differences and associated variation in climatic factors and soil fertility (Takele *et al.,* 2014). The contribution of browse species as a source of animal feed is influenced by a number of factors such as the natural distribution of the browses within the agro-ecological zones, the distribution, type and importance of livestock, their integration and role within the farming system and availability of alternative sources of fodder for livestock in the agro-ecological zone.

It is difficult to measure the amount of leaf produced by browse species as it is influenced by age of browse species, defoliation and rainfall. Direct measurement of biomass is usually a long and tedious task. Studies show that the foliage biomass is correlated with the circumference of the trunk, the height of the trees and the area of the crown (Petmark, 1983 and Cisse, 1980). Significant and positive correlation between the actual forage DM yield and petmarks estimate of forage DM yield for *Acacia saligna* was reported earlier (Getachew, 2005).

The productivity of foliage yield per unit area has been found to be linked with habitat and soil texture. Some browses in favorable humid and sub-humid climate situations were reported to produce from 2.3 to 4.69 tons DM forage per hectare per year (Bauner, 1992). Leaf biomass yield of 1 to 4.3 tons per hectare were reported (Lemma *et al*., 1996). Total biomass production can be manipulated by tree density and cutting interval. A high density and long interval results in a high DM yield per hectare.

2.3. Nutritional Qualities of Feed Resources

Feed quality means the ability and the extent to which feed has the potential to produce a desired animal response. Thus the quality reveals the level of nutrient (chemical) composition, palatability and intake, digestibility, anti-nutritional factors and animal production performance (Abeysekara, 2003). The nutritive value of ruminant feed is determined by the concentration of its chemical compositions, as well as rate and extent of digestion in the rumen. The most practical approach to feed analysis is one of chemical composition direct determinations of dry matter, ether extract (fat), ash (mineral), nitrogen (crude protein), and fiber fractions.

Natural pastures mostly suffer from seasonally spells of dry periods during which they drop in quality, which is characterized by high fiber content, low digestibility, and low in nitrogen, very low protein and energy content (Assefu, 2012). The yield as well as quality of pasture is very low due to poor management and over stocking (Ashagre, 2008).

The nutritive value of natural pasture in the central highlands of Ethiopia is low. It has low protein content, high amount of fiber and also low digestibility (Seyoum and Zinash, 1989; Zinash *et al.*, 1995 and Solomon, 2004). Low digestibility is a major factor constraining voluntary intake of high-fibre low-protein roughage in ruminants. These are the high cell wall contents and the low content of rumen degradable nutrients, especially nitrogen (N) and sulphur (S) and also low content of micro and macro minerals (Leng, 2009a).

Dry matter contains the essential nutrients within a given feed ingredient or forage. Feeds, and thereby diets, vary widely in their dry matter content. Pasture feeds have dry matter content usually have greater than 85% DM. Feed protein content is often considered a good determinant of quality. Low crude protein (CP) diets may result in rumen degradable protein deficiency and impact negatively on rumen fermentation and microbial synthesis, decreasing metabolizable energy and protein availability for livestock. As indicated in Kazemi *et al*. (2012), legumes, grasses and grass-legume mixtures containing greater than 19% CP are rated as having prime standard and those with CP values lower than 8% are considered to be of inferior quality. The CP content of pasture and hay is less than 7%, which is very much below the requirement for adequate microbial function in the rumen (Van Soest, 1982). The protein content of hay on DM basis was usually less than 5%, which is below the level of maintenance requirement for ruminants (Solomon *et al.*, 2008a). Deribe *et al*. (2013) reported that the crude protein contents of grass species varied widely ranging from 1.42%-18.95% in southern Ethiopia. The poor nutritive values of grasses and their lower degradability results in low intake and utilization and thereby reduced the performances of animals (Solomon *et al*., 2004).

The quality of legumes and grasses can be assessed by the type and quantity of fibrous material in the plant. Neutral detergent fiber is the cell wall material of the plant and is comprised of the hemicelluloses, cellulose, and lignin. This proportions of cellulose, hemicelluloses and lignin effects the digestibility of the NDF fraction. With the less digestible forages, fewer nutrients are provided to the animal for production or growth (Kawas *et al*., 1989). Increasing levels of NDF in plants and/or diets have been found to limit dry matter intake. Forage NDF has a slower passage rate and a higher rate of digestion than most non forage NDF (Mertens, 2002). Differences in the rate and extent of digestion of NDF and ruminal digestibility of NDF are related to volatile fatty acid production and ultimately the ability of feed to maintain ruminal pH (NRC, 2001).

Acid detergent fiber is comprised of cellulose and lignin and is closely associated with digestibility. An increase in the indigestible lignin complex in the ADF fraction reduces digestibility of the plant. Therefore, ADF and digestibility are negatively correlated. Both NDF and ADF increase as the plant matures causing a decline in the quality of the forage (Jim Linn and Carla kuehn, 2007). According to Mtimuni (1996) lignin percentage decreased with increasing maturity of the cereal forage due to increasing grain to stem and leaf ratio.

Crop residues are generally characterized by relatively low nutrient content, low CP, minerals and vitamins and high fiber contents, low digestibility and low voluntary intake (limited consumption) by animals. Crop residues are potentially rich sources of energy as about 80% of their DM consists of polysaccharide, but usually underutilized because of their low digestibility, which limits feed intake (FAO, 2002). According to the report of Deribe *et al.* (2013), the CP content of feed samples of different crop residues was low in which ranges from 2.01-8.97% at southern Ethiopia. Seyoum and Fekede (2008) also reported that the cereal crop residues are normally characterized by low digestibility and energy value, which are both inherent in their chemical composition. The nutrient supply of many cereal straws such as teff, barley and oat straws is closer to the nutrient supply of medium quality native grass hay. Thus good quality straw can be regarded as a good roughage source for livestock next to native grass hay (Adugna, 2008).

The crop residues have long been known as important maintenance for livestock. However, when used alone, they are of very low feeding value with poor metabolizable energy, negligible available protein and seriously deficient in mineral and vitamins. On the other hand, crop residues vary greatly in chemical composition and digestibility depending on varietal differences and agronomic practices. The feeding value of crop residues is also limited by their poor voluntary intakes, low digestibility and low nitrogen, energy, mineral and vitamin contents (Alemu *et al*., 1991).

Crop residues are fibrous and high in lignin content, which limit the feeding value (McDonald *et al.*, 2002 and Adugna, 2009). The dry matter (DM) content of all crop residues was above 90% in both agro ecologies, which agreement with Zewdie *et al*. (2011) and Solomon *et al.* (2008). The crude protein content is insufficient to fulfill even the maintenance requirement of animals (Rehrahe and Ledin, 2004). Solomon *et al.* (2008) reported that all crop residues had higher than 70% NDF contents. Roughage feeds with NDF content of less than 45% are categorized as high quality, 45-65% as medium quality and those with more than 65% as low quality roughages (Sigh and Ousting, 1992). Kellems and Church (1998) categorized roughages with less than 40% ADF as high quality and those above 40% as low quality. They are inherently low in crude protein, digestibility and intake and are deficient in minerals (Rehrahe, 2001). The lower nutrient contents reduce rumen efficiency, rumen micro-fauna and milk production performance. Hence, proper supplementations, with agro-industrial byproducts and/or concentrates, are suggested to make animals produce (Melese, 2008 and Girma, 2010). However, such supplements are out of the reach for the poor farmers due to cost and availability (Nurfeta, 2010). Another more practical way to improve the nutritional status of livestock is to include fodder trees, which are rich in protein and are already available and have a good chance to be integrated into the existing farming system (Alemayehu, 2006 and Mapiye *et al*., 2009).

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 (Reddy and Elanchezhian, 2008). Compared to grasses, fodder trees and shrubs have relatively high concentrations of crude protein and minerals (Bisrat, 2014; Belete *et al.*, 2012 and Takele *et al.,* 2014).

2.4. Factors Affecting Quantity and Quality of Feed Resources

Nutritive value of a given feed is generally determined by nutrient composition, intake and utilization efficiency of digested matter. Yield and nutritional qualities of pasture are influenced by numerous factors representing ecological conditions and management activities. Those factors include frequency of cutting, species composition, and maturity stage of the plant, climatic conditions, soil fertility status and season of harvesting (Yihalem, 2004). The poor crude protein content of feed was due to poor pasture management, land fragmentation and degradation; overgrazing and overstocking, soil type, plant species and maturity stage (Deribe *et al*., 2013).

A variation in chemical composition and feeding value of herbage was observed with stage of plant growth; the crude protein, minerals and vitamins content decreased and the cellulose, hemicelluloses and lignin increased with advanced stage of growth (McDonald *et al*., 2002). As pasture gets mature, it is characterized by high content of fiber with a higher grade of lignifications and low protein content. The NDF and ADF contents in the control increased from 47.5 to 66.9 % and from 22.4 % to 42.9 % and CP decreased from 6.8 to 4.8% at 30 and 120 days of harvesting, respectively (Adane and Berhan, 2007).

The diversified species composition of the natural pastureland is a desirable attribute in terms of pasture quality, quantity and persistence (Ashagre, 2008). The more the proportion of the legume to the grass composition, the higher the crude protein content of the mixed stand and bring better productivity on the animals (Yihalem, 2004).

Environmental effects on forage composition are complex; however, temperature, light and moisture in decreasing order are the dominant factors affecting the plant physical nature and composition chemistry (Van Soest, 1994). High temperatures have negative effect on crude protein and ash composition, but positive effect on crude fiber content of temperate pasture species (Van Soest, 1982). High temperature has a depressing effect on dry matter digestibility. Low temperatures also influence the drive for increased stem diameter, plant height, and leaf stem ratio, decreased lignifications and delayed maturity. High light intensity has a negative effect on CP, CF, lignin and ash content (Van Soest, 1982). Light and photoperiod promote photosynthesis and the production of sugars and metabolites that dilute the structural matter, hence a negative association between light and cell wall components (Van Soest *et al*., 1978). Low moisture levels in soil delay plant maturity, decrease plant height, increase leaf stem ratio and can decrease NDF percentage.

The nutritive value of crop residues are also variable depending upon the species and variety of the crops, time of harvest, handling and storage conditions and other factors (Ahmed *et al*., 2010). Crop residues are mostly stored by stacking them outdoor near homesteads (Ahmed *et al.*, 2010 and Mulugeta, 2005). Decay due to sun light and unexpected rain or moisture condition was the major storage problem of almost all types of crop residues that could affect the quality and quantity of crop residues efficient utilization.

2.5. Balance between Nutrient Supply and Requirement by Livestock

Besides, the major feed resources used for DM supply were natural pasture, crop residues and stubble grazing, fodder trees and cultivated forages, agro industrial by-product, other by-products like food and vegetable refusal. Assessment on the quantity and quality of available feed resources in relation with livestock requirement has not been yet well addressed in most livestock production areas.

Generally, livestock require nutrients for maintenance, growth, production and reproduction. Nutrients required for these functions are expressed in terms of energy, protein, minerals (particularly calcium and phosphorous) and vitamins. Metabolizable energy and digestible protein requirements were taken as the major limiting constitutes for animal maintenance and production. Van Soest *et al.* (1985) underlined the importance of determining digestible protein and required energy, as they are the first two limiting factors for livestock productivity. According to Blümmel *et al.* (2009), feed metabolizable energy (ME) content should be used as an important determinant of livestock productivity; and water requirement for feed and fodder production should be related to a unit of feed ME rather than feed bulk. Energy, protein and digestibility of feeds are central in determining nutritional adequacy and feeding levels for different classes of stock (Streeter, 2006).

Energy for maintenance can be defined as the amount of feed energy required for essential metabolic processes and physical activities, which results in no net loss or gain from, or to the tissues of the animal (NRC, 1996). The requirement of animals for nutrients depends on the species of animals, aim of production (milk, meat and power) and the level of performance (Esubalew, 2002). Productivity of ruminants is a function of digestible feed intake and the efficiency with which the absorbed nutrients are used for productive purposes.

The dry matter and metabolizable energy were below the annual livestock requirements in highland of Ethiopia (Bedasa, 2012). The feed balance in terms of DM, DCP and ME supply for total TLU per annual was much lower with a negative balance (Yisehak and Janssens, 2014). Senbeto *et al.* (2010) also reported the annual DM production could satisfy only two-third of the total DM requirements of the livestock due to this, during the dry season animals lose their condition which is an indicator of feed shortage and suggests that livestock production and productivity are constrained by feed scarcity in highland of Ethiopia. Contrastingly surplus DM supply than the total annual livestock requirement in North Gondar (Sisay, 2006) and the nutrient balance in the DM supply of the feed in Metema District is sufficient to support the livestock per household (Tesfaye, 2008). These positive values reported may be related to the small livestock population in the area and also the fertility of the land favoring feed production.

2.6. Livestock Feeding Systems

Relevant information required for the development of feeding system, primarily, on the quantity and quality of available feed resources is limited in Ethiopia. Feeding of livestock in different places differs depending on forage availability, climatic variability of a given location or region to mitigate feed shortage problems during worse conditions, season of the year and type of animal the owner prioritize to feed (Beyene *et al.*, 2011). Endale (2015) identified indoor, group feeding, let to graze and tethering are the types livestock feeding practiced in Meta Robi of west Shewa zone.

Natural pasture is utilized for grazing or hay or as green feed by cut and carry system of feeding. Grazing is the predominant form of ruminant feeding system in most part of the extensive and smallholder crop-livestock farming areas in Ethiopia (Getachew, 2002 and Solomon, 2004). Tesfaye (2008) identified free grazing/browsing, cut and carry system and tethering are the feeding system practiced in Metema District of North Gondar.

Crop residues can be grazed in the form of stubble or offered to animals after collecting the material from the field. Animals are fed on crop residue mainly in two ways. The residues are piled in stacks near homesteads and animals are let to feed from the stacks or given small quantities in the mornings and evenings; or for working oxen, before and after work. Alternatively, the residues are left on the threshing ground and consumed by animals together with the standing straws, which are left for aftermath grazing. In some parts of the Ethiopian central highlands, there is a strong tendency towards improving the utilization of crop residues by supplementing with molasses and/or urea (Daniel, 1988). Agro-industrial by-products are fed as supplement to roughage based diets, particularly in livestock production system for dairying or per urban fattening activities. They could be utilized by mixing two or more of the ingredients to make concentrate at home or using a single ingredient (Yoseph, 1999).

3. MATERIAL AND METHODS

3.1. Description of the Study Area

3.1.1. Location

The study was carried out in Lalo kile district which is found in Kellem Wollega Zone of Oromia Regional State. The district is located at a distance of 510km West of Addis Ababa, capital city of Ethiopia. It is astronomically located at latitude and longitude of 08° 25' 56"N and 034°33'41"E. Currently, the district covers an estimated area of 403.82km^2 and divided in to 22 rural and one urban kebeles (ADO, 2015).

3.1.2. Agro ecology and Topography of the Study Area

The district is situated at an altitude ranging from 1430 to 1780 meters above sea level. An agro-ecological setting of the district comprised of mid altitude (60%) and low altitude (40%) and receives rainfall ranging from 1,000 – 1,500 mm per annum. In normal years, the rainy season extends from April to October. The minimum and maximum daily temperatures of the area are 15^{0}C and 31^{0}C respectively (ADO, 2015).

The soil types of the district are classified into three groups on color: - black soil (one of the best and most fertile can suffer acidity and N-fixation and become erodible), white soil (soil with more clay and unproductive) and red soil (soil with sandy, affected by erosion, loss of fertility and low level of organic matter) (ADO, 2015).

3.1.3. Demographic Structure

According to agricultural district office reports (2015); the total households of the district are estimated at 7,797, of which 7,157 are male headed and 640 are female headed households. The total population of the district is 49,783; of which 23,760 are males and 26,023 are females. The crude density of the population is thus 123.28persons/km^2.

3.1.4. Economic Activities

The farming system of the district is characterized by mixed farming system, comprising both cropping and livestock production. The district is characterized by rain-fed production system of a wide range of cereals, pulses, oil seed crops and livestock husbandry practices. The major crops grown in the district are maize, sorghum, finger millet, teff, haricot beans, beans, peas, vegetables for consumption and coffee, pepper, noug, sesame are for cash crops and the minor crops are wheat, barley, sweet potatoes, fruit and Irish potatoes. Maize stover, finger millet, sorghum and teff straw constitute the largest share of crop residue fed to livestock in the district.

Table 1: Total land area and Livestock population in Lalo kile district

No	Total land		Livestock holding	
	Type of land	Area (ha)	Livestock class	Livestock population
1	Cultivable land	24,065.00	Cattle	103,674
2	Communal grazing land	1,342.00	Sheep	43,126
3	Natural forest	1292.93	Goats	26,234
4	Degraded land	2019.10	donkey	9,854
5	Water body cover	1580.00	Horse	4,340
6	Others	10082.97	Mule	3,211
7	Total	40,382.00	Chicken	44,583

Source: ADO and LDHCD (2015)

3.2. Sampling Procedure and Methods of Data Collection

3.2.1. Sampling Procedure

For this study, stratified random and purposive sampling techniques were used to select the kebeles and households, respectively. According to the Cochran (1977) sampling procedure, the district is stratified in to two agro-ecological zones, mid altitude from 1500-2000m.a.s.l.and low altitude from less than 1500 m.a.s.l. After all the twenty three kebeles in the district were grouped into the respective stratum; six kebeles from both strata were randomly selected.

Lists of model farmers obtained from each randomly selected six kebeles were used to develop a sampling framework. Thus, the representative sample size was determined at 95% of confidence interval from selected area by using the following formula (Cochran, 1977).

$$n = \frac{z^2 p(1-q)}{d^2}$$

Where**:** n is the sample size,

z is static for a level of confidence

p is expected prevalence or proportion (in proportion of 10%)

d is the level of precision which is ±5%.

Finally, by using the household engaged listed from the selected kebeles, 127 representative sample farmers were selected by using the reduced formula (Table 2).

$$n_1 = \frac{no}{1+\frac{no}{N}} = \frac{138}{1+\frac{138}{1650}} = 127$$

Accordingly, 66 households from the three randomly selected kebeles of mid altitude and 61 from the three randomly selected kebeles of low altitude zones were purposively selected for the interviews based on the potential of crop and livestock production, and accessibility for data collection.

Table 2: The proportion of representative households from agro ecologies for interviews

Name of selected Kebeles	Total number of Households	Proportion of households	Number of sample households
	1650	1	127
Mid altitude	858	0.52	66
A/Kucho	390	0.23	30
Seggo	260	0.16	20
F/Jirru	208	0.13	16
Low altitude	792	0.48	61
H/Abote	259	0.16	20
Wabera	351	0.21	27
M/Kallisa	182	0.11	14

Source: Data from kebele (2015)

3.2.2. Methods of Data Collection

A structured questionnaire was prepared and pre-tested before being administered, then refining and a correction was made in accordance to the respondents' perception. Both the primary and secondary data was used during data collection. The primary data was collected from smallholder farmers of six randomly selected kebeles, whereas secondary data or supplementary information are obtained from livestock development and health care agency, agricultural office of the district, land and environmental protection office of the district, kebele leaders and development agent. The respondents were visited individually at their premises after making appointment with the researcher. The interviews were carried out at the farmer's home to enable counterchecking of the farmer's response with respect to the availability of potential feed resources.

The data were collected by interviewing household heads engaged in small scale livestock production in the area. Thus, the households were interviewed on demographic and farming system characteristics, objective of livestock keeping, herd size and composition; major available feed resources in terms of type, quantity, importance, quality, availability by season and feeding calendar (natural pasture, crop residues, industrial by products, cultivated forages, browse trees, non-convention feed and others), conservation practices, coping mechanism to feed shortage, feeding systems and constraints related to feed resources.

3.3. Assessment of Feed Resources and Quantity Estimation

3.3.1. Determination of Species Composition of Feed Resources in Natural Pasture

To determine the potential natural pasture biomass yield and dry matter production in the study area, representative samples of grasses, legumes and other herbaceous vegetation were taken from the sites of high, medium and low vegetation covers based on grazing pressure according to Thairu and Tessema (1985) and visual observation according to Mannetje (2000). The proportion of grasses, legumes and other herbaceous species were assessed at the time of pasture grasses had reached almost 50% flowering stage when vegetative growth usually stops. The measurements were carried out on natural pasture (communal grazing, private grazing, fallow lands and roadside areas) by using 1 meter by 1 meter quadrants according to Mannetje (1978) and Tarawali *et al*. (1995). The quadrant was placed randomly by throwing a piece of stone towards the back on selected areas high, medium and low vegetative covers of grazing land. All the samples inside the quadrant were harvested at 5cm above ground level, the composites were mixed together and the total fresh weight was obtained by direct measurement and converted to the total area of grazing land. Seventy two sub-samples (18 quadrates each from private, communal, fallow land and roadside feeds) were sampled from both agro ecologies. On the whole, 24 composites sampling unit were employed from both agro ecologies. The dry matter yield of each species was determined in an oven (65^{o} C for 72 hours) at animal nutrition laboratory of Jimma University College of Agriculture and Veterinary Medicine. Based on the DM weights obtained from sample sites, percent composition of each species of grasses, legumes and herbaceous species for each quadrant was calculated and the total biomass production capacities of the area were obtained as follows according to Tothil *et al.* (1978):

$$\text{TDW of individual species} = \frac{\text{TFW of a species}}{\text{SFW of a species.}} \times \text{SDW of species}$$

$$\%\ \text{Composition of each species at a site} = \frac{\text{TDW of a species}}{\text{GTDW of all the species}} \times 100$$

Where, TFW is total fresh weight of individual species, SFW is sub-sample fresh weight, SDW is sub-sample dry weight, TDW is total dry weight and GTDW is grand total dry weight of all species.

The potential yield of fodder trees and shrubs were estimated by measuring steam diameter using measuring tape and applying the equation of Petmark (1983). The circumference of the selected trees and shrubs were measured and the numbers of each species within the randomly laid quadrant of 20 x 20 m in the grazing land was counted from both altitudes. The yield per plant was estimated by cutting the branches and collecting the edible part followed by weighing (leaves and shoots) of the tree. The diameter of the plants was calculated using the formula; D=0.636C where D is the diameter and C is the circumference of the plant. The potential yield of each browsing plant was calculated by using the following formula developed by Pet Mark (1983).

$$\text{LogW}=2.24\text{logDT}-1.5, \text{ for tree}$$

$$\text{LogW}=2.62\text{logDS}-2.46, \text{ for shrubs}$$

Where, W was leaf DM yield in kg, DT was diameter of trunk (cm) at 80 cm height (for tree leaf biomass) and DS was diameter of stem (cm) at 30 cm height (for shrub leaf biomass).

3.3.2. Quantity Estimation of Feed Resources

The quantity of dry matter production obtainable from natural pastures was estimated by multiplying the hectare under each land use category by using conversion factors. The conversion factors of 3.0 t /ha for private grazing land, 1.8 t/ha for fallow land, 2.0t/ha for communal grazing, 0.50 t/ha for stubble crops, 8t/ha for improved forages and 1.2t/ha for wood, bush and shrubs (FAO, 1984). The quantity of dry matter basis of non-conventional and concentrates (supplements) feed resources available were estimated by interviewing the farm owners with regard to the amount supplied per day, and frequency and quantity purchased per month respectively.

The quantity of crop residues in the study area were estimated using the information on crop production and land area collected from the respondents. The quantity of dry matter (DM) output from major crop residues was estimated by conversion of grain yields to fibrous residues using multipliers of 1.5 for wheat, barley, oats and emmer wheat, 1.2 for field pea, faba bean and linseed, 2.0 for finger millet, 0.3 for sugar cane, sweet potato and other root & tubers, 4 for noug and linseed, 0.25 for vegetables waste, and 8 for banana (FAO, 1987). Maize stover estimated a multiplier of 2 (de Leeuw *et al.*, 1990) and sorghum 2.5 was used (Kossila, 1988). About 10% of the crop residues is considered as wasted either during utilization or used for other purposes (Adugna and Said, 1994).

3.4. Determination of Nutritive Value of Feed Resources

3.4.1. Collection of Feed Samples

The sample feeds were collected for chemical analysis in dry season in January to March and wet season in late July to August to conduct the chemical composition and nutritive values of feed resources based on agro ecology. While identifying the available feed resources, the households were requested to rank the major natural pasture feeds, crop residues, different fodder trees and shrubs based on their palatability (preference by livestock) and their dominance and by their ability to maintain greenness. Based on the rank, the most common species of these feed types were collected for chemical analysis. Natural pastures from communal grazing, private grazing, fallow land and roadside grazing land were harvested randomly from different quadrates per grazing land of each agro ecologies using $0.5 * 0.5m^2$ quadrates at mid growth stage of sample feed by using sickle. After removing the non edible plant species by livestock, the sub-samples harvested from the high, medium and low vegetation covers of the same species were thoroughly mixed to make one composite sample and stored in sample bags. The crop residues samples were collected from different farm households for chemical analysis on their actual production calendar of crops, and make composite sub-samples by mixing the same species and stored in sample bag until to analyze.

3.4.2. Chemical Analysis of Sample Feed

The various samples of feed resources collected during cross sectional field survey (herbaceous and woody species collected from natural pastures, fallow land, stubbles feeds, road side, household compound, bush land and other places, crop residues (straw & stover), non conventional feedstuffs were processed and subjected to proximate analysis and the neutral detergent fiber and acid detergent fiber components following the official procedures indicated below at animal nutrition laboratory of Jimma University College of Agriculture and Veterinary Medicine.

The sample feeds which high moisture content was dried in an oven at 65^{o}C for 72 h. All the feed samples were ground to pass through a one mm sieve size using Willey mill. The dry matter, total ash, crude protein, crude fiber, crude fat and acid-detergent fiber were determined according to AOAC (1995). The percentage organic dry matter was calculated by reducing total ash from 100%. Neutral-detergent fiber determination was following Van Soest *et al*. (1991) procedures. NDF was analyzed without a heat stable amylase and expressed exclusive of residual ash. The ADF result was expressed without residual ash.

Metabolizable energy content of each feed resources for tropical forages and concentrates was estimated by multiple regression model and summative equation developed by Abate and Meyer (1997).

$$\text{ME (MJ/kg DM)} = 5.34 - 0.1365\text{CF} + 0.6926\text{NFE} - 0.0152\text{NFE}^2 + 0.0001\text{NFE}^3$$

Where NFE = %DM - (%EE + %CP + %CF + %Ash) (McDonald *et al.*, 2010). Acid insoluble ash was determined to reduce sand and silica from total ash content of feed resources and Sodium sulphite (Na_2SO_3) is included in CF determination in order to remove tannins from CF: tannin complexes.

The Digestible Crude Protein (DCP) of feed resources was estimated according to the equation developed by FAO (1986).

$$\text{DCP (g/kg)} = 0.929 \times \text{CP (g)} - 3.52$$

3.5. Estimation of Dry matter, Crude Protein and Metabolizable Energy Contents of Feed resources in relation to Animal Requirements

The feed supply balance estimation was done from major data sets of supply side which was estimated from household survey and biomass harvested dry matter yield. The total energy requirements of livestock types were calculated as the sum of the maintenance energy requirements of livestock. To compare balance, the number of livestock population was converted into tropical livestock units using the conversion factors of Kearl (1982) and Wilson (1984). The total available dry matter, nutrients supplied as metabolizable energy and digestible crude protein was estimated by summation of the nutrients supplied by each category of major feed resources.

In demand side estimation, the maintenance requirements of total DM from major feed resource were calculated by 6.25 kg DM/day. This is 2.5% of body weight of the animal. The digestible crude protein requirement for maintenance was 160g digestible protein per day (FAO, 1986) for one tropical livestock unit (250 kg body weight). Since in the study area there are not exotic breeds available, the conversion was only for indigenous tropical livestock unit. For estimation of metabolizable energy maintenance requirement livestock, a standard method developed by King (1983) for tropical regions was used.

Maintenance energy requirement was calculated according to the following equation:

$$\mathbf{ME} = \frac{\mathbf{0.343} XLW^{\mathbf{0.73}}}{km}$$

Where by ME is ($MJday^{-1}animal^{-1}$) for maintenance; LW is the live body weight, km ($MJkg^{-1}$) is the efficiency with which ME is used for maintenance and related the average forage metabolizability and always tends to lie 0.64-0.70.Thus, the metabolizable energy(ME) of one tropical livestock unit was 29.84 MJ kg/day/animal.

3.6. Statistical Analysis

The data were organized and analyzed with the help of Statistical Package for the Social Sciences (SPSS version 20, 2012). Descriptive statistics such as frequency, means, percentages and standard errors were used to analyze qualitative data in the mixed crop-livestock production system including land holding and uses, herd size and structure, and available feeds and feeding systems. The GLM ANOVA model was used to analyze the quantitative data and least significant difference at $p<0.05$ level tests were used. Pearson`s coefficient of correlation analyses was used to test the magnitude and direction of relationship between different variables such as total land holding, total cultivated land, private grazing land, fallow land ,roadside, communal grazing land, livestock size (TLU) and DM production of crop residues.

A simplified model for data collected on yield and chemical composition of feed samples was analyzed using the following statistical model as follow:

$$Y_{ijk} = \mu + \alpha_i + \beta_{ij} + e_{ijk}$$

Where: Y_{ijk} = Quantity and quality of feed available

μ = Overall mean

α_i = the effect of i^{th} agro-ecology (i=1-2)

β_{ij} = the effect of j^{th} study season (j=1-2)

e_{ijk}= random error

4. RESULT AND DISCUSSION

4.1. Demographic and Socio Economic Characteristics of the Households

4.1.1. Household Characteristics

The household characteristics of the study area were presented in Table 3. About 89.4%, 10.6% in mid and 91.8%, 8.2% in low altitude were male headed and females headed households, respectively. The marital status of the sampled households was 83.8%, 10.6%, 6.1% in mid and 88.5%, 8.2%, 3.3% in low altitude area were married, widow and widower, respectively. About 47% of the households were the follower of orthodox, 47% of protestant and 6.1% was Muslim in mid altitude area. In low altitude area, about 65.6% householders were follower of protestant whereas the remaining 24.6% and 9.8% are Orthodox Christian and Muslim, respectively.

In mid altitude area, about 22.7% and 34.8% of the respondents have attended their secondary and primary schools, respectively. While in lowland area, 4.9% and 16.4% of respondents have attended secondary and primary schools, respectively (Table 3). Thus, the educational level of the households was better in mid altitude area than Low altitude area. The difference could be attributed to better access of schools in the mid altitude area compared to the low altitude area. Farmers with educated levels adopt usually new technologies more rapidly than lower educated farmers in study area.

Table 3: Demographic characteristics of the households in the mid and low altitude areas

Demographic characteristics	Mid altitude area		Low altitude area		Total	
	N	%	N	%	N	%
Sex of Households						
Male	59	89.40	56	91.80	115	90.60
Female	7	10.60	5	8.20	12	9.40
Total	66	100.00	61	100.00	127	100.00
Educational status of households						
Illiterate	17	25.80	36	59.00	53	41.70
Read and write	11	16.70	12	19.70	23	18.10
Primary school(1-8)	23	34.80	10	16.40	33	26.00
Secondary school & above	15	22.70	3	4.90	18	14.20
Total	66	100.00	61	100.00	127	100.00
Marital status of households						
Married	55	83.30	54	88.50	109	85.80
Widow	7	10.60	5	8.20	12	9.40
Widower	4	6.10	2	3.30	6	4.70
Total	66	100.00	61	100.00	127	100.00
Religious of households						
Orthodox	31	47.00	15	24.60	46	36.20
Muslim	4	6.10	6	9.80	10	7.90
Protestant	31	47.00	40	65.60	71	55.90
Catholic	00	00	00	00	00	00
Total	66	100.00	61	100.0	127	100.00

N=Number of households

The average family size of the households in the district was 6.45 ± 0.16 (ranging from 4-9).The family size of the households was 5.78±0.21 in mid and 7.18±0.23 in low altitude areas of the study district (Table 4). In low altitude area, the average family size was relatively higher than mid altitude and this might be due to difference in family planning program among farmers and educational levels indicated above. Generally in the study district, the average family size of the respondents was higher than national average family size of rural areas (4.9) per household (CSA, 2011) and this is mainly due to labor demanding agricultural activities in the area contributed for such higher family sizes.

The average age of the surveyed household headed in the study area was 46.79±1.29 (ranging from 27-65) and 42.98±1.27 (ranging from 26 - 68) years in mid and low altitude area, respectively. The overall average age of the surveyed household headed in the study district was 44.96±0.92 with the minimum value of 26 and the maximum value of 68 years old. The result was lower than the mean age of 48.10±12.66 years reported by Endale (2015) in Meta Robi district of the west shewa zone but greater than the mean age 40.16±0.84years reported by Tesfaye (2008) in Metema district of North Gondar.

Table 4: Age and Family size characteristics of the households in the study area (Mean ±SE)

Agro-ecology	Age of household				Family size		
	N	Min.	Max.	Mean ±SE	Min.	Max.	Mean ±SE
Mid altitude	66	27	65	46.79±1.29	4	9	5.78±0.21
Low altitude	61	26	68	42.98±1.27	4	9	7.18±0.23
Means	127	26	68	44.96±0.92	4	9	6.45±0.16

N=Number of householder SE= SE=standard error

4.1.2. Land Holding and Land Use Pattern

The average land holding of the respondents was smaller in the mid altitude area (2.62± 0.05ha per household) as compared to 3.05 ± 0.17ha per household in low altitude area (Table 5). The average landholding of the respondents in the study district was higher than the average national landholding size (0.96 ha/hh) and Oromia region (1.15 ha/hh) (CSA, 2011). This might be due to availability of land in the study area. Farmers in the study areas allocate land to different use and cover type. About 71.37% of the land holding was allocated for cultivated land and land allocated for coffee and forest, private grazing land, fallow land and communal grazing land were 14.12%, 7.25%, 3.05%, 1.15% in mid altitude area, respectively. While in low altitude area, about 59.11% of land was allocated for crop production and only 13.39% was covered by livestock grazing land (private and communal grazing land). Households in the low altitude area had significantly ($p<0.01$) larger private farm size than in mid altitude. This was due to the availability of larger size of land per household in lower altitude area.

Allocation of grazing land within a household depends on agro-ecologies and farming system. Across the study district, the share of grazing land ranges between 8.4% and 13.39% in mid and low altitude areas, respectively (Table 5). The private grazing land holding varies between the agro ecologies. This was due to decreased communal grazing land in mid altitude area, farmers decided to separate private grazing land from own crop land area to their livestock. The results therefore, indicate that more animals are maintained on a small plot of grazing land and the bulk of the feed comes from crop residues. This has resulted in overgrazing of the small grazing land, poor biomass productivity and limited productivity potential due to poor quality of feed from crop residues. Hence this may lead to the depletion of feed resources through overgrazing, contributing to the low productivity of livestock (Alemayehu, 2002; Birhanu *et al*., 2004) and to food insecurity (Devereux, 2000).

In general, the households in the study district allocated about 1.84 ±0.05ha (65.02%) for crop production and 0.13± 0.01 ha (4.60%), 0.18± 0.03ha (6.36%), 0.44±0.02ha (15.54%) for private grazing, communal grazing and coffee land, respectively. Bedasa (2012) reported that the amount of land size allocated for crop production was 1.7 ha (70%) and grazing land was 0.4 ha (16.6%) in Jeldu district, west shewa zone. Shitahun (2009) also reported the average land allocated for different crops per household was 1.55ha (77.62%) and private grazing was 0.04ha (3.14%) in Bure district, Amhara region.

Table 5: Average land holding and use patterns per household in study area (ha)

Types of land use	Mid altitude area	Low altitude area	Over all	*p-value*
	N=66	N=61	N=127	
	Mean ± SE	Mean ± SE	Mean ± SE	
Crop land	1.87±0.04	1.81 ± 0.10	1.84 ±0.05	<.001
Private grazing land	0.19 ±0.01	0.06± 0.01	0.13 ± 0.01	<.002
Communal grazing land	0.03± 0.01	0.33 ± 0.04	0.18 ± 0.03	<.001
Fallow land	0.08±0.01	0.18 ±0.03	0.13 ± 0.02	<.001
Roadside	0.04±0.01	0.05 ±0.01	0.04 ± 0.01	<.036
Coffee and forest land	0.37±0.02	0.52 ± 0.02	0.44 ±0.02	<.001
Woody land	0.04±0.01	0.11 ± 0.02	0.07 ± 0.01	<.042
Total	2.62± 0.05	3.05 ± 0.17	2.83 ±0.09	<.0001

N = number of respondents, SE = Standard Error

4.1.3. Livestock Holding, Herd structure and Purpose of Livestock Rearing

The average number of livestock holdings per household was presented in Table 6. It shows that TLU values ranged between 7.11±0.61 and 8.63± 1.08 per household in mid and low altitude area, respectively. The highest value was estimated for low altitude area of livestock farming system. The result was relatively similar with Bedasa (2012) who reported the livestock holding of TLU was 7.42±0.47 in Jeldu district, west shewa zone.

Average holdings of total livestock per household in the low altitude area were relatively higher than in mid altitude area. This may be due to more communal grazing land and fallow & woody land availability from which higher proportion of livestock feed is derived in low altitude than in mid altitude of the study district. Cattle were the dominant livestock species accounted for about 61.62% in mid and 68.16% in low altitude with average of 65.22% in both agro ecologies. The average number of cattle were significantly different ($p<0.01$) within the altitude area and this might be related to land holding and potential difference of an individual resources.

The mean of sheep and goats holding per household were significantly different ($p<0.01$) with in altitude and this might be related other means of income generation especially from coffee in the study area (Table 6). The average TLU holding of sheep and goats per household was estimated at 0.25±0.03 and 0.15±0.03 in mid altitude and 0.24±0.02 and 0.16±0.02 in low altitude area, respectively. The average number of donkeys, horses and mules per household in the mid altitude area were higher than in low altitude area, which might be related to better adaptation to the environment and for transportation.

The herd composition of cattle in both agro ecologies was dominated by cow, bulls, calves and heifers, respectively. Generally, in both agro ecologies the herd structure was female dominated as compared to male. This shows male animals being used only for traction and latter transferred to fattening for selling. Similarly, the trend of herd structures in small ruminant was female dominated.

The main objectives of livestock rearing in the study district were for draught power and income generation. In the study district, all respondents indicated that cattle are used for drought power, household milk consumption and for manure; small ruminant for income generation, and donkey and horses for transportation when farm produce is harvested. This result was agreement with the report of Zewdie (2010).

Table 6: Livestock holding and species composition (Mean ±SE) per household and TLU in the study areas.

Livestock species	Mean of livestock per household			TLU(Tropical Livestock unit)		
	Midland	Lowland	Over all mean	Midland	Lowland	Over all mean
Cattle	8.56 ± 0.61	10.98±1.35	9.77± 0.78	5.99±0.43	7.69±0.94	6.84±0.62
Pregnant	0.96±0.14	1.67±0.16	1.30±0.11	0.77±0.11	1.34±0.13	1.06±0.12
Lactating	1.65±0.17	1.96±0.25	1.80±0.15	1.32±0.13	1.57±0.20	1.45±0.16
Heifers	1.65±0.20	1.80±0.29	1.72±0.17	0.83±0.10	0.90±0.15	0.86±0.12
Bull	2.47±0.21	3.62±0.44	3.02±0.24	2.72±0.23	3.98±0.48	3.35±0.35
calves	1.83±0.14	2.01±0.25	1.92±0.14	0.36±0.02	0.40±0.05	0.38±0.08
Sheep	2.53± 0.27	2.44 ± 0.24	2.48± 0.18	0.25±0.03	0.24±0.02	0.24±0.02
Ewe	1.19±0.11	1.21±0.12	1.20±0.08	0.12±0.01	0.12±0.01	0.12±0.01
Ram	0.42±0.11	0.40±0.07	0.41±0.05	0.04±0.01	0.04±0.01	0.04±0.01
Lamb	0.89±0.12	0.80±0.10	0.85±0.08	0.09±0.01	0.08±0.01	0.08±0.01
Goats	1.51± 0.27	1.78 ±0.21	1.64± 0.17	0.15±0.03	0.18±0.02	0.16±0.02
Doe	0.65±0.11	0.68±0.07	0.67±0.06	0.06±0.01	0.07±0.01	0.06±0.01
Buck	0.50±0.12	0.65±0.10	0.57±0.08	0.05±0.01	0.07±0.01	0.06±0.01
Kids	0.34±0.07	0.44±0.10	0.39±0.06	0.03±0.00	0.04±0.01	0.04±0.01
Donkey	0.98±0.11	0.62 ± 0.09	0.81±0.07	0.49±0.05	0.31±0.04	0.41±0.04
Horse	0.21 ±0.04	0.15 ± 0.05	0.18± 0.03	0.17±0.04	0.12±0.04	0.14±0.02
Mule	0.15±0.04	0.06± 0.00	0.11± 0.03	0.11±0.00	0.05±0.00	0.08±0.00
Total	13.94±0.90	16.03± 1.72	14.98 ± 0.95	7.11±0.61	8.63±1.08	7.87±0.84

SE= Standard error, TLU=Tropical Livestock unit

4.1.4. The Interdependency of Crop-Livestock Production Sectors

The correlation between different parameters in the study district was presented in Table 7. The total crop land holding ($p<0.01$, r =0.88) was significant and positively correlated with total land holding, private grazing land holding ($p<0.01$, r =0.30), fallow land holding ($p<0.01$, r =0.67) and communal grazing land holding ($p<0.01$, r=0.79). Whereas roadside feed ($p<0.05$, r = 0.12) was not significant but negatively correlated with total land holding in the district.

The total livestock holding ($p<0.01$, r=0.79) was significantly and positive correlation with total crop land production ($p<0.01$,r=0.73), private grazing land ($p<0.01$,r=0.27), fallow land ($p<0.01$, r=0.60) and communal grazing land($p<0.01$,r=0.60). The result of the study was similar to the report of Solomon *et al.* (2009) who observed herd size correlated with landholding, cultivated land and grazing land in the Sinana Dinsho district of Bale highland. The roadside feed resources ($p<0.05$, r=0.25) was significant and negatively correlated with total crop production and total livestock holding but not with private and communal grazing land in the study district. The total DM production from crop residues ($p<0.01$, r=0.79) was high significant positively correlated with total crop land ($p<0.01$, r=0.89) and total livestock holding in the study district.

The positively correlation between total crop land and total livestock holding in the study district indicates that livestock contribute to increased cultivated area through provision of drought power and supply of agricultural inputs. The positive correlation between crop residues and livestock holding was as major feed resources for livestock in dry season.

Table 7: Correlation between different parameters considered in the current study

Parameters	Total land holding(ha)	Total crop land(ha)	PGL(ha)	FL(ha)	RS(ha)	CGL (ha)	Livestock size (TLU)	Crop residue (TDM)
Total land holding(ha)	1.000							
Total crop land(ha)	0.887**	1.000						
PGL(ha)	0.309**	0.322**	1.000					
FL(ha)	0.676**	0.445**	0.141	1.000				
RS (ha)	-0.120	-0.251**	-0.038	-0.147	1.000			
CGL(ha)	0.787**	0.536**	0.047	0.573**	-0.032	1.000		
Livestock size(TLU)	0.795**	0.733**	0.272**	0.609**	-0.182*	0.606**	1.000	
Crop residues(TDM)	0.739**	0.893**	0.352**	0.326**	-0.223*	0.358**	0.580**	1.000

** Correlation is significant at the ($p<0.01$) level;*correlation is significant at the ($p<0.05$) level; N=127; PGL=Private grazing land; FL=Fallow land; RS= Roadside feed; CGL=Communal grazing land; TLU =Tropical livestock unit; TDM= Total dry matter from crop residue

4.2. Major Livestock Feed Resources Available during Dry and Wet Season in the Study Area

The major feed resources available during varied seasons are presented in Table 8. Sufficient and quality livestock feed resources availability are some of the major determinants of livestock productivity. The availability of feed resources varied in seasons and agro ecologies with respect to type, quantity and quality of feed. The principal dry season feed resources available for livestock in the study area includes crop-residue (34.49%), stubble grazing (8.13%), shrubs and fodder trees (15.60%), non-conventional feed (4.46%), root tubers, fruit and vegetable waste and very little milling byproducts in their descending order of magnitude. Whereas in wet season, the principal feed resources were natural pastures (36.0%); of which private grazing land (13.07%), communal grazing land (11.48%), fallow land (8.64%) and road side (2.81%), stubble grazing (like haricot bean and barley), improved forages (1.32%), weeds and others in their descending order of intensity of use by producers in the study district. Tesfaye (2008)reported the major feed in dry season are natural pasture (55.7%), crop residues (20.7%), stubble (14.3%) and hay (9.3%) and in wet season natural pasture is sole feed resources of livestock in Metema district of north Gondar.

The contribution of each of the feed ingredients to the diet of livestock as perceived by farmers (qualitatively) and estimated dry matter production of each ingredient varies between agro ecologies of the study area. Their contribution to the total feed resource base varies from area to area based on cropping intensity (Seyoum et *al*., 2001). Most of farmers under estimation of crop residues role in livestock feed, bulk of crop residues produced goes to waste. Generally, natural pasture in wet season and crop residues in dry season were the dominant feed resources in the study district. Thus in wet seasons, all of the respondents (100%) in both altitudes use natural pasture followed by fodder shrubs to their livestock.

Table 8: The proportion livestock feed resources available in wet and dry season of the study area

Feed resources (%)	Agro ecologies				Overall mean (%)		
	Mid altitude (%)		Low altitude (%)				
	Wet	Dry	Wet	Dry	Wet	Dry	Total
Natural pasture(grazing)	36.39	4.00	29.11	1.25	32.75	3.25	36.00
*Private grazing	16.22	3.65	4.02	2.25	10.12	2.95	13.07
*Communal grazing	6.84	-	16.12	-	11.48	-	11.48
*Fallow grazing land	9.94	-	7.34	-	8.64	-	8.64
*Roadside feed resources	3.39	0.35	1.63	0.25	2.51	0.30	2.81
Fodder trees & shrubs	4.15	8.25	3.00	15.80	3.58	12.02	15.60
Non-conventional feed	-	2.38	-	6.53	-	4.46	4.46
Improved forage	0.83	0.83	0.33	0.65	0.58	0.74	1.32
Crop residues	2.50	40.67	1.24	40.84	1.87	40.75	42.62
*Crop residues	-	35.14	-	33.84	-	34.49	34.49
*Stubble crops	2.50	5.53	1.24	7.0	1.87	6.26	8.13

4.2.1. Natural Pasture Feed Resources

Natural pasture is one of the major livestock feed resources in wet season which includes grasses, legumes, other herbaceous, weeds, and fodder shrubs and trees in the study area. Natural occurring pastures provide 51.6% of the livestock feed resources in the study district with a wide range of grasses, legumes and other herbaceous. The present result was relatively similar with Endale (2015) who reported natural pasture grazing provides 58.9% in Meta Robi district of west Shewa zone.

The proportions of private and communal grazing land were 19.87%, 6.84% and 6.27%, 16.12% in mid and low altitudes of the study area, respectively (Table 8). Ahmed *et al*. (2010) reported grazing on either private grazing land (PGL) or communal grazing land (CGL) is a common practice following the onset of rain in most parts the country. The private grazing land was significant different ($p<0.01$) between mid and low altitude of the study area. This is because private grazing land was more practiced in mid altitude area as a common source of livestock feed in wet season than in low altitude area. However, in low altitude area communal grazing land was as a common source of livestock feed in wet season than in mid altitude area.

The most valued grass species identified were *Digitaria abyssinica, Pennisetum clandustinum*, *Pennisetum sphocelatum*, *Snowdine polystarch and Pennisetum purpureum* and the legume species identified were *Medicago burweed, Vigna vexillata* and *Cucumis ficifolius* in both agro ecologies of study district (Table 9). Indigenous grass species reported by the number of authors in different areas (Tesfaye, 2008; Solomon *et al*., 2007 and Habtamu *et al*., 2012). The availability of grasses like *Snowdine polystarch* and *Plantago lanceolata L.* species was the characteristics for degraded areas, due to heavy grazing pressure.

Table 9: List of the major grasses, legumes and herbaceous species identified as important to livestock feeds in study area

Scientific name	Vernacular Name (Afan Oromo)	% of res-pondents(n)	Edible parts	Livestock species	Type of fodders
Pennisetum clandustinum	Coqorsa	95.4%(63)	leaf, twigs	Cattle,sheep,goat, donkey	Grasses
Digitaria abyssinica	Warati	97.6%(124)	leaf	Cattle,sheep,goat, donkey	Grasses
Pennisetum sphocelatum	Migra	74.8%(95)	leaf	Cattle,sheep,goat, donkey	Grasses
Berchemia discolor	Jajjaba	42.6(26)	leaf	Cattle, donkey, horse, mule	Grasses
Snowdine polystarch	gargaara	67.7%(86)	leaf	Cattle,sheep,goat, donkey	Grasses
Plantago lanceolata L.	qorxobbi	46.4%(59)	leaf	Cattle,sheep,goat, donkey	Grasses
Dignathia hirtella Stapf	Qamboo	31.1(19)	leaf	Cattle, donkey, horse, mule	grasses
Panicum hochstetteri Steud.	Marga gogorri	23%(14)	Leaf	Cattle, donkey, horse, mule	Grasses
Pennisetum purpureum	Elephant grass	72.4%(92)	Leaf	Cattle,sheep,goat, donkey	grasses
Medicago burweed	Siddisa	57.4%(73)	Leaf	Cattle,sheep,goat, donkey	legumes
Trifoliu burchellionum	Hasangira	31.8%(21)	Leaf	Cattle,sheep,goat	Other herbs
Grewia bicolor Juss	Haroressa	24.6%(15)	Leaf	Cattle,sheep,goat, donkey	legumes
Vigna vexillata L. A. Rich.	Gurra hantuta	69.3%(88)	Leaf , twigs	Cattle,sheep,goat, donkey	legumes
Cucumis ficifolius A. Rich	Facaa`a	52.0%(66)	Root	Cattle, goats	legumes

4.2.1.1. Species Biomass Composition from Natural Pastures

In the study district, a total of 32 species edible by livestock were identified. Of these, 15 were different species of grasses while 17 were different non-grass species. Among the non-grass species, 12 species were legumes whereas 5 species were other herbs (Appendix Table 1). Thus, study area was dominated by annual grass, legume and other herb species. This was due to continues grazing pressure on limited land and poor management of natural pastures in study area. Herlocker *(*1999) suggested that overgrazing reduces ground cover, plant height, forage quality and productivity, and perennial grasses which are replaced by annual grass and herb species.

The average biomass yield obtained from private, communal, roadside and fallow land in the study district is presented in Table 10. Decline of the areas and dwindling of biomass productivity of grazing lands in the study areas are some of the major concerns. The average dry matter production of grasses, legumes and herbaceous were 1.206t/ha, 0.974 t/ha, 0.212t/ha respectively from private grazing land and 1.14t/ha, 0.12t/ha, 0.09t/ha from communal grazing land in mid altitude area. Whereas in low altitude area, 1.242t/ha, 0.282t/ ha, 0.234t/ha from private grazing land and 0.975t/ha, 0.04t/ha and 0.11t/ha from communal grazing land, respectively. The biomass and dry matter production was significantly different ($p<0.05$) between the two agro ecologies of the study area. The result shows how the heavy and continuous grazing pressure ultimately decreased biomass production in low altitude area as compare to mid altitude of the study district. Alemayehu and Amaha (2006) reported that overgrazing might have been the main factor for the decline in the composition and diversity of plant species over a long period of time.

In general, the average dry matter yield of biomass composition grasses, legumes and other herbaceous were 1.156t/ha,0.242t/ha and 0.182t/ha with the overall 1.58tons/ha in study district, respectively. The result was relatively similar with Zewdie (2010) who reports with the average dry matter yield from grasses, legumes and forbs were 1.172t/ha, 0.0127t/ha and 0.048t/ha around Ziway, central rift valley of Ethiopia. The present result was lower than Beyene *et al*. (2010) reports with the average dry matter yields of grasses, legumes and others herbs from natural pasture were 1.891t/ha, 0.399t/ha and 0.205t/ha in shifting cultivation and 1.251t/ha, 0.218t/ha and 0.216t/ha in permanent farming system ,respectively at Asosa zone of western Ethiopia. This variation might be related to low livestock pressure in that area.

The overall grasses species represents 73.13% of the DM biomass production while legumes and herbaceous were only 15.32%, 11.55% in the study district. Zewdie (2010) reported the average DM biomass composition of grasses was (86.1%), legumes (2.2%) and herbs (11.7%) in similar study around Ziway, central rift valley of Ethiopia. The ways people use and manage the grazing pasture influences the quality and quantity, as well as seasonal distribution (Thompson, 2007) and also affect the composition of species lead to palatable and nutritious species being replaced by unpalatable species.

Table 10: Species biomass composition and dry matter production from private, communal, fallow land and roadside feed resources

Feed resources		Mid altitude				Low altitude				Average			
		grass	legume	herbs	total	grass	legume	herbs	total	grass	legume	herbs	total
Private grazing	Fresh wt (t/ha)	4.63	4.11	2.22	10.96	5.63	1.15	1.93	8.71	5.13	2.63	2.075	9.835
	Dry w/t (t/ha)	1.206	0.974	0.212	2.392	1.242	0.282	0.234	1.758	1.224	0.628	0.223	2.075
	Biomass (%)	50.42	40.72	8.86	100	70.65	16.04	13.31	100	58.99	30.26	10.75	100.0
Communal grazing	Fresh wt (t /h)	3.91	0.73	0.72	5.36	3.97	0.25	0.73	4.95	3.94	0.49	0.725	5.155
	Dry w/t (t/ha)	1.140	0.120	0.090	1.350	0.975	0.040	0.110	1.125	1.057	0.080	0.100	1.237
	Biomass (%)	84.44	8.89	6.67	100	86.66	3.56	9.78	100	85.45	6.47	8.08	100.0
Fallow land	Fresh wt (t/h)	4.33	1.46	0.40	6.19	5.07	0.51	0.33	5.91	4.70	0.985	0.365	6.05
	Dry w/t (t/ha)	1.260	0.240	0.050	1.550	1.245	0.080	0.050	1.375	1.253	0.160	0.050	1.463
	Biomass (%)	81.29	15.48	3.23	100	90.54	5.82	3.64	100	85.64	10.94	3.42	100.0
Roadside	Fresh wt (t/h)	3.80	0.67	3.39	7.86	4.36	0.57	1.92	6.85	4.08	0.62	2.65	7.35
	Dry w/t (t/ha)	1.110	0.110	0.420	1.640	1.070	0.090	0.290	1.450	1.090	0.100	0.355	1.545
	Biomass (%)	67.68	6.71	25.61	100	73.80	6.20	20.0	100	70.56	6.47	22.97	100.0
Total	Fresh wt (t/h)	4.167	1.74	1.68	7.59	4.75	0.62	1.22	6.60	4.46	1.18	1.45	7.09
	Dry w/t (t/ha)	1.179	0.361	0.193	1.733	1.133	0.123	0.171	1.427	1.156	0.242	0.182	1.580
	Biomass (%)	68.03	20.83	11.14	100	79.40	8.62	11.98	100	73.13	15.32	11.55	100.0

W/t=weight; t/ha=tons/hectare

4.2.1.2. Quantity of Dry matter Production from Natural Pasture

The average annual dry matter production obtained from total private grazing land, communal grazing land, fallow land and roadside of the surveyed households were presented in Table 11. About 2.5± 0.04tons and 0.86±0.02ton in mid and 0.70 ± 0.05ton and 1.80 ± 0.07tons in low altitude area were the mean annul dry matter production per household from private grazing land and communal grazing land, respectively. The total dry matter production from private and communal grazing land was significantly different ($p<0.01$) between the two agro ecologies of the study district. This due to allocation of land differences for livestock feed resources. This result was greater than Yeshitila (2008) reports, the average dry matter production per household were 0.93±0.10ton, 1.58± 0.19tons from private grazing land and 0.02±0.01 ton, 0.10±0.04ton from communal grazing land in the two farming systems respectively at Alaba district, southern Ethiopia. This was due to plots of land owned by the household in study area.

Table 11: The mean annual dry matter production from private, communal, fallow and roadside grazing areas of the study district (tons per household)

Grazing area	Mid altitude	Low altitude	Over all mean	*p-value*
	N=66	N=61	N=127	
	Mean ± SE	Mean ± SE	Mean ± SE	
Private grazing land	2.5 ± 0.04	0.70 ± 0.05	1.6±0.03	< .002
Communal grazing land	0.86 ± 0.02	1.80 ± 0.07	1.33±0.04	< .001
Fallow land	1.25± 0.02	0.82 ± 0.05	1.03±0.03	< .001
Roadside	0.47±0.01	0.21±0.02	0.34±0.01	< .037
Total	5.08 ±0.09	3.53±0.17	4.30±0.11	< .0001

N=Number of respondents, SE=standard error

4.2.2. Feed Resources from Fallow land

Fallow land was one of the livestock feed resources in the study area. Grasses (*Digitaria abyssinica*, *Snowdine polystarch),* legumes *(Medicago burweed, Vigna vexillata* L. A. Rich) and weeds (*Ageratum conyzoides*, *Bidens rueppellii*, *Aspilia mossambicensis* and *Trifoliu burchellionum*) are the common species in fallow land area in study district.

In the study area, the average biomass dry matter production of grasses, legumes and other herbs were 1.26 t/ha, 0.24t/ha and 0.05t/ha from mid and 1.245t/ha, 0.08t/ha and 0.05t/ha from low altitude area, respectively. In general, the average dry matter yield of biomass composition grasses, legumes and weeds were 1.253t/ha, 0.16t/ha and 0.05t/ha in study district, respectively (Table 10).

The average quantity of annual dry matter production obtained from fallow land of the surveyed households was 1.25± 0.02 and 0.82 ± 0.05tons per households in mid and low altitude area, respectively (Table 11). The dry matter production from fallow grazing land was significantly different (0.01) between the two agro ecologies of the study area. This was due to the fact that farmers in mid altitude practiced fallow land to increase soil fertility then livestock feed. The present result was greater than the finding of Dawit *et al.* (2013) who reported the average dry matter production per household was 0.14 ± 0.03tons at Adami Tullu Jiddo Kombolcha district of Ethiopia. This was due to shifting cultivation practiced in study area.

4.2.3. Roadside Feed Resources

In the past the main feed resources were natural pastures (especially communal grazing land), fodder trees and shrubs, and fallow land grazing. However, this situation has been changed now due to rapidly increasing human population (Adugna, 2007) and increases the demand for food, thus pushing for a conversion of pastures into crop land (Alemayehu, 2006; Girmay *et al*., 2010 and Amare, 2013). Similarly, in the study area farmers use different mechanisms to cope up with feed shortages allow their livestock to graze on roadside, riverside and swampy areas.

The average biomass dry matter production of grasses, legumes and herbs were 1.11t/ha, 0.11 t/ha and 0.42t/ha from mid and 1.07t/ha, 0.09t/ha and 0.29t/ha from low altitudes of the study area, respectively. The average dry matter yield of biomass composition of grasses, legumes and herbs were 1.09t/ha, 0.10t/ha and 0.355t/ha in study district, respectively (Table 10). The present result was less than Beyene *et al*. (2010) who reported that the average dry matter yields of grasses, legumes and others herbs from river side were 1.651tons/ha, 0.415tons/ha and 0.332ton/ha in shifting cultivation and 0.884tons/ha, 0.33tons/ha and 0.168tons/ha in permanent farming system, respectively at Asosa zone, western Ethiopia. This might be related to livestock pressure and low soil fertility in the study area.

The average annual dry matter production obtained from roadside grazing land of the surveyed households was 0.47±0.01 and 0.21±0.02ton per household in mid and low altitude areas, respectively (Table 11). The average dry matter production from roadside feed resources was significantly different ($p<0.05$) between the two agro ecologies of the study area. This was due to greater biomass dry matter yield of roadside grazing land in mid altitude than low altitude area. The present result was disagreement with Tesfaye (2008) who reported the total dry matter production of roadside feed resources was 2.75tons in Metema district, North Gondar. This might be related to available roadside grazing land in the area.

4.2.4. Feed Resources from Crop residues and Stubble grazing

4.2.4.1. Crop Residues

Crop residues are one of the dominant feed sources in the district especially during the dry season of the year. In mid altitude area, the major crop residues available for livestock feeding included residues from cereals (maize, sorghum, finger millet, teff, wheat and barley), pulses crops (haricot bean, soy bean, bean and pea), oil seed (nug chuff and linseed) and root & tubers (sweet potato and pumpkin). Among the cereal crops, maize, finger millet and sorghum are the major crops grown in mid altitude which account for 54.62 % of the total crop-residues are which produced in the area. In low altitude area, maize, finger millet, sorghum, haricot bean, sesame and potatoes are the crops produced in the area.

Among those crops grown in the study area, about 66.74% of crop residues are obtained from finger millet, sorghum and maize. The total area of crop land and available crop residues from finger millet, sorghum and maize in low altitude area were significantly higher ($p<0.01$) than the mid altitude area. This was due to finger millet; sorghum and maize were common family food consumption in the low altitude than in mid altitude of the study area. Teff and wheat production was significantly different ($p<0.05$) between the two agro ecologies and this was both teff and wheat are agro ecologically productive in mid altitude rather in low altitude of the study district.

The quantity of DM obtained from crop residues and stubble crops in surveyed household are presented in Table 12. The mean annual DM production from crop residues was 4.76±0.01 and 4.19±0.19tons in mid and low altitude area with the average DM production 4.48±0.12tons per household, respectively. The total dry matter production from crop residues was significantly different between the two agro ecologies of the study area. This was due to type and amount crop production difference in agro ecologies. Overall in the study area, the total utilizable DM production from cropping system was 4.03±0.11TDM per household. The result was less than Dawit *et al*. (2013) who reported total utilizable DM production from cropping system was 10.9±1.1 and 8.5±0.5 TDM per household in rural and peri urban of Adami Tullu Jiddo Kombolcha district, respectively. This might be due to intensity cultivation, post harvest handling and efficient utilization of crop residues in the study area.

Table 12: The Mean ± SE of dry matters production from crop residues and stubble crops per household and its utilization (tons)

Variable	Midland N=66		Lowland N=61		Over all N=127		*p-value*
	Mean ±SE	%	Mean ±SE	%	Mean ±SE	%	
Maize	0.91±0.03	19.12	1.11±0.07	26.49	1.01±0.05	22.54	<.001
Sorghum	0.81±0.04	17.02	1.03±0.04	24.58	0.92±0.04	20.54	<.001
Finger millet	0.88±0.03	18.49	1.25±0.04	29.83	1.06±0.40	23.66	<.001
Teff	0.55±0.02	11.55	-	-	0.28±0.01	6.25	<.001
Wheat	0.33±0.02	6.93	-	-	0.17±0.01	3.79	<.004
Noug	0.69±0.06	14.50	0.22±0.05	5.25	0.46±0.05	10.27	<.001
Haricot bean	0.12±0.01	2.52	0.26±0.03	6.21	0.19±0.02	4.24	<.001
Barley	0.12±0.02	2.52	-	-	0.06±0.01	1.34	<.086
Bean & pea	0.09±0.01	1.89	-	-	0.04±0.01	0.89	<.248
Sweet potato	0.06±0.00	1.26	0.13±0.00	3.10	0.09±0.00	2.01	<.078
Vegetable	0.05±0.00	1.05	0.03±0.00	0.72	0.04±0.00	0.89	<.049
Sesame	-	-	0.16±0.04	3.82	0.08±0.02	1.79	<.027
Soybean	0.15±0.01	3.15	-	-	0.08±0.01	1.79	<.008
Over all	4.76±0.10	100.00	4.19±0.19	100.00	4.48±0.12	100.00	<.0001
Utilizable (90%)	4.28±0.01	90.00	3.77±0.19	90.00	4.03±0.11	90.00	<.0001
Stubble crops	1.01±0.03	-	0.92±0.05	-	0.96±0.03	-	<.001

N=Number of householder; SE = Standard error

4.2.4.2. Collection, Storage and Utilization of Crop Residues

The collection of crop residues and storage practices were observed to depend on the mechanism of harvesting grain from the crops. In the study area, collection of crop residues followed after harvesting of the grain. With finger millet, teff, wheat, noug, barley and haricot bean, collection of grains from the harvested crops and transporting of the crops to homesteads where they are threshed and their grain and straws are separated. Finally the straws are collected near homesteads and in some cases, fenced with locally available wood. Gezu *et al.* (2014) reported farmers usually harvest crop residues together with the grain and after threshing conserve the straw in a stack for emergency use in Lemo and Soro district, southern Ethiopia. In case of maize and sorghum, the maize stalk and sorghum grain heads are usually removed from the stalk right in the field leaving the rest for grazing.

The storage of crop residues and form of utilization of surveyed households is shown in Table 13. Farmers understand the fact that crop residue is one of the major feed resources to rely on but very few of them store in a separate cottage to cope up the long period of feed scarcity of four to six months. As a result, most of the crop residues are hipped up outside in the field or discarded and wasted by trampling. In mid altitude area, about 48.5%, 39.4% and 12.1% of the respondents were store crop residues as stacked at open field, bale under shade and stacked under shade respectively. While in low altitude area, 67.21%, 24.59 and 8.19% of respondents were store crop residues as stacked at open field, bale under shade and stacked under shade, respectively. This was critical effects on nutritional qualities crop residues.

About 42.42% and 49.18% of the respondents provides crop residues to their livestock two months after collection in mid and low altitude of the study area, respectively. Endale (2015) reported that the 17.8% of respondents were providing crop residues two months after collection in Meta Robi district. Longer storage time of crop residues before feeding in both agro ecologies might be related with shortage of additional feed reserves for draught oxen during plowing periods.

The respondents provides crop residues to their livestock in different ways (Table 13) in which, 83.3%, 6.0%, 3.0% and 7.5% in mid and 96.7%, 0%, 0% and 3.3% in low altitude area of the respondent practiced whole feeding, chopped, treated the feed and mix crop residues with other feeds, respectively. As overall in study district, 89.7%, 3.2%, 1.6% and 5.5% of respondents provided crop residues as whole, chopped, treated and mixed with other feeds, respectively. Similar to the current finding, Endale (2015) reported that feeding crop residues in whole (72.2%), chopped (16.7%), treated straw (3.3%) and mixed with other feeds (7.8%) was practiced at Metta robi district. Generally, in the study district, most of the farmers fed crop residues as whole feeding and this increase wastage of the feed and reduce efficient utilization of the available feeds.

Table 13: Methods, length of storage and form of feeding crop residues to livestock

Variable	Midland	Lowland	Over all
	N=66	N=61	N=127
Method of storage			
Stacked at open field	32(48.50%)	41(67.21%)	73(57.48%)
Stacked under shade	8(12.10%)	5(8.19%)	13(10.23%)
Bale under shade	26(39.40%)	15(24.59%)	41(32.28%)
Length of storage			
Soon after collection	6(9.09%)	4(6.55%)	11(8.66%)
One month after collection	12(18.18%)	15(24.60%)	27(21.25)
Two month after collection	28(42.42%)	30(49.18%)	57(44.88%)
Over two month after collection	20(30.30%)	12(19.70%)	32(25.19%)
Form of feeding crop residues			
Whole	55(83.30%)	59(96.70%)	114(89.70%)
Chopped	4(6.00%)	0(0.00%)	4((3.20%)
Treated	2(3.00%)	0(0.00%)	2(1.60%)
Mixed with other feeds	5(7.50%)	2(3.30%)	7(5.50%)

4.2.4.3. Stubble Grazing

Stubble crop is one of the important livestock feed sources in study area. After harvesting the crops, livestock are allowed to graze stubble of different crops (maize, sorghum, finger millet, wheat, teff, barley, haricot bean and others) mainly from November to December. Linear relationship existed between areas of land cultivated and types of crops produced by households except when the difference comes due to difference in production rate of the crops and height of harvest. For the first two months, the stubble is grazed by the animals of the farm owner and later it becomes accessible to all animals in the community (Ahmed *et al*., 2010).

According to the survey results, values of 1.01± 0.03 and 0.91± 0.05 in mid and low altitude areas and an overall value of 0.96 ± 0.05 were the dry matter production tones per household. The present result didn`t agree with Yeshitila (2008) who reported values of stubble crops 1.17 ± 0.08, 1.56 ± 0.11 in farming system I and II and an overall value of 1.34 ± 0.71 tones per household in Alaba district, south Ethiopia. Farmers in the study district use stubble grazing as one means to sustain their livestock for duration of about 2-3 months starting from November to January.

4.2.5. Fodder Trees and Shrubs

Fodder (browse) is an agricultural term for animal feed, and fodder trees and shrubs are those plants (shoots or sprouts, especially tender twigs and stems of woody plants with their leaves, flowers, fruits or pods, wood ash) that are raised, used and managed to feed livestock. As a major source of animal feeds in the study area, fodder trees and shrubs are highly valued by farmers during dry season. These forage species contain appreciable amounts of nutrients that are deficient in other feed resources such as grasses during dry seasons and dry periods. Fodder trees and shrubs are important components of ruminant diet and they have been found to play important roles in the nutrition of grazing animals in areas where few or no alternatives are available Babayemi and Bamikole (2006) and as feed, fuel wood and as human and veterinary medicines (Luseba and Van der Merwe 2006).

The lists of common shrubs and fodder trees identified during survey assessment were the locally important for potential livestock feed resources during dry season were presented in Table 14, where the scientific names, vernacular name, percentage of respondent, edible parts by the livestock and the animal groups that most favored the feed are indicated. There are about 51 different indigenous shrubs and fodder tree species were identified (25 species of shrubs and 26 species of trees) in the study area (Appendix Table 1). Almost all plant species were browsed by livestock but the degree of palatability varies from season to season and species to species. The most favorable time to utilize browse in the study area is late in the dry season between late February to April, when the grazing and other feed resources are at their poorest condition or even non-existent. Cattle and sheep selected the most palatable grasses and legumes during the wet season, while goats browsed on trees and shrubs. As the herbaceous component become more abundant and nutritious during the wet season, cattle and sheep are less attracted to the browse species. However, during the dry season, the herbaceous components are less abundant and often become more fibrous. In this season cattle and sheep depend first on leaves and succulent twigs of browse species. As the dry season progresses, however, less palatable species are also browsed by livestock during the critical dry season. According to the respondents, the wood ash fodder trees like *Bersama abyssinica* and *Schefflera abyssinica* are important for fattening purpose.

In the study district, the most widely utilized browse species, as indicated by the interviewed households are presented in Table 14. Some of most palatable livestock were *Sapium ellipticum* (93.3%), *Rhoicissus tridentata* (87.8%), *Vernonai amygadalina* (82.5%), *Ficus sur Fossk* (82.3%), *Acanthus polystachius* Delile (81.8%), *Rubus apetalus* Poir (78%), *Albizia gumifera* (73.3%), and others. The result was agreement with Belete *et al.* (2012) who reports potential fodder trees and shrubs in mid rift valley of Ethiopia. The potential available resources of fodder trees and shrubs in different areas are reported by different of authors (Abebe *et al.*, 2008; Diriba *et al*., 2013; Mulugeta and Kindu, 2013 and Takele *et al*., 2014). The contribution of browse species as a source of animal feed is influenced by a number of factors such as the natural distribution of the browses within the agro-ecological zones, the distribution, type and importance of livestock, their integration and role within the farming system and availability of alternative sources of fodder for livestock in the study district.

Table 14: List of major shrubs and trees species identified as important to livestock feeds in Lalo kile district

Scientific name	Vernacular Name (Afan Oromo)	% of res-pondents(n)	Edible parts	Livestock species	Type of fodders
Rhoicissus tridentata	Laaluu	87.80%(58)	Leaf, twigs	Cattle(calf),sheep, goats	shrubs
Acanthus polystachius Delile	Sokorru	81.80%(104)	Leaf, twigs	Goats &sheep	shrubs
Teclea nobilis	Gurshane	62.30%(38)	Leaf, twigs	Cattle, sheep & goats	shrubs
Combertum paniculatum	Baggee	65.30%(83)	Leaf	Cattle ,goats	shrubs
Myrsine africana L.	Qacama dima	68.80%(42)	Lea f	Cattle sheep and goats	shrubs
Zehneria scara	Hidda reffa	63.90%(39)	Root	Cattle	shrubs
Sapium ellipticum	Bosoqa	93.30%(118)	Leaf ,twigs	Cattle, sheep & goats	tree
Ficus sur Fossk	Harbu	82.30%(104)	Leaf, pods	Cattle & goats	tree
Bersama abyssinica	Lolchisa	68.50%(87)	Wood ash	Cattle	tree
Schefflera abyssinica	Afarfattu	66.40%(84)	Wood ash	Cattle	tree
Combretum collinum	Dhandhamsa	66.00%(40)	Leaf	Cattle, sheep, goats	tree
Ficus ovata	Dambi jabbi	90.00%(59)	Leaf, twigs	Cattle, sheep & goats	tree
Mcraceae (family name)	Madalle	78.30%(48)	Leaf ,twigs	Cattle, sheep &goats	tree
Ficus thonningii Blume	Dambii	69.10%(87)	Leaf	Cattle, sheep &goats	tree
Albizia gumifera	Ambabeessa	73.40%(93)	Steam	Cattle, sheep &goats	tree
Vernonai amygadalina	Ebicha	82.50%(54)	Leaf, twigs	Cattle sheep & goats	tree
Rubus apetalus Poir	Goraa	78.00 %(51)	Leaf	Cattle, sheep & goats	tree

The biomass yield of shrubs and fodder trees in low altitude area was higher than mid altitude area of the study district. The variation among species in biomass yield suggests differences in potential biomass yield that may be associated with differences in growth of the species and availabilities the species. It also appears that there is variation in biomass yield among kebeles within each species, which may be related to spatial differences and associated variation in climatic factors and soil fertility.

Generally, the average biomass dry matter yields of fodder trees and shrubs were 7.98-19.78kg/ tree and 1.06- 2.41kg/shrub in mid and 9.87-178.06kg/tree and 1.34-3.87kg/shrub in low altitudes of the study area. Takele *et al*. (2014) reported the biomass yields of selected indigenous fodder tree/shrubs 24.55kg/tree/shrubs to 958.76kg/tree in Wolayta zone, southern Ethiopia.

The total biomass dry matter production of fodder shrubs and trees was estimated 74.36-100kg/ha and 500-800kg/ha in cultivated land and uncultivated land edible by livestock in study area, respectively. The result was less than browses in favorable humid and sub-humid climate situations were reported to produce from 2.3 to 4.69 tons DM forage per hectare per year (Bauner, 1992) and leaf biomass yield of 1 to 4.3 tons per hectare were reported (Lemma *et al*., 1996). Total biomass production can be manipulated by tree density and cutting interval. A high density and long interval results in a high DM yield per hectare.

Table 15: The biomass yields (kg) of selected indigenous fodder trees at the 80cm height and shrubs at 10cm height of the two agro ecologies

Tree species	Biomass yield/tree(kg)	Shrubs species	Biomass yield/shrub(kg)
Mid altitude			
Sapium ellipticum	19.78	*Rhoicissus tridentata*	1.06
Ficus ovata	16.95	*Combertum paniculatum*	2.41
Rubus apetalus Poir	7.98	*Ricinus comiunis*	1.34
Vernonai amygadalina	9.87	*Ficus palmata* Forsk	1.15
Ficus sur Fossk	19.78	-	-
Cordial africana	16.95	-	-
Low altitude			
Ficus thonningii Blume	62.14	*Myrsine africana L.*	1.49
Madalle	27.95	*Acanthus polystachius*	3.60
Combretum collinum	19.78	*Teclea nobilis*	3.87
Ficus vasta Forssk	178.06	*Coronopus didymus*	1.34
Syzygium guineanse	49.07	-	-
Grewia ferruginea	9.88	-	-

4.2.6. Improved Forage Feed Resources

The use of improved forages as livestock feed resources was not well adopted by farmers in both agro ecologies of the study area. The proportion of improved forages available was 1.66% in mid and 0.98% low altitude with overall 1.32% of proportion of feed in the study district. Only few farmers in both agro ecologies of the study area had grown *Sesbania sesban, Leucaena leucocephala*, *Vernonai amygadalina* and *Rubus apetalus* at the back yard both for the purpose of coffee shade and livestock feeds and *Pennisetum purpureum, chloris gayana, Avena saliva, lablab purpureas* at the small plot of land used it as livestock feed. Firew and Getinet (2010) reported that oats and vetch are conventionally cultivated in arable lands either in pure stand or in mixture, while most other forage crops are established in the backyards, fence lines, field borders and stock exclusion areas.

Cultivated forage and pasture crops are mainly important as cut and carry sources of feed and as a supplement to crop residues and natural pastures (Adugna, 2008) and higher feed quality of paramount importance in mixed crop livestock systems(Bedasa, 2012). However in the study area, almost all of the farmers did not establish and utilize improved forages as livestock feed. According to the respondents in the mid altitude area, the reasons why they did not adopted an improved forages are lack of land to grow improved forage as major problem, shortage of availability of improved forage seed and depends on purpose of livestock production. While in the low altitude area, communal grazing land perception, lack of awareness and lack of improved seed in are the problem identified.

4.2.7. Non-conventional Feed Resources

Some of the non-conventional feed resources in the study area are banana leaf and steam, *enset*, sugar cane leaf, coffee pulp, mango kernel, chat leaf, waste of local areke (*Atela*) and others (Table 16). Most non-conventional resources are usually regarded as waste which is an inaccurate description in the study area. Utilization of the non-conventional feeds resources in the different agro ecologies is different. In the study area, banana leaf and *enset* were utilized by 36.3 and 28.6% of the respondents in the low altitude and banana leaf and local extraction (*atela*) were more utilized in the mid altitude by 33.3% and 33.2% of respondents, respectively. Yeshitila (2008) identified non- conventional feeds and it includes residues of local drinks coffee, *areke,* a*tela, chat* left over called *geraba,* fruits and vegetables reject.

Table 16: Major non conventional feed resources reported by respondents in percentages (N=127)

Feed resources	Agro ecology					
	Mid altitude (n=66)		Low altitude (n=61)		Over all mean (n=127)	
	Wet season	Dry season	Wet season	Dry season	Wet season	Dry season
Banana steam & leaf	-	33.30	-	36.30	-	34.65
Enset	-	15.20	-	28.60	-	21.90
Mango kernel, papaya	15.40	18.30	*	*	7.70	9.10
Sugar cane leaf	-	4.30	-	18.60	2.15	9.30
Coffee pulp	**	**	**	**	**	**
Atela(local extraction)	18.00	15.20	25.7	10.60	21.85	12.29
Chat leaf	8.40	12.70	5.8	8.40	7.10	10.55
Pumpkin	*	14.50	*	9.70	*	12.10
Nug chuff	*	16.80	*	14.70	*	15.75
Straw & pod of pulse crops	12.60	8.70	2.4	8.30	7.50	8.50

(**) =Not known as livestock feed; (*) not available; (-) not palatable in the season

4.2.8. Source of Water, Watering system and watering frequency

The sources of water, watering systems and watering frequency of livestock in the study area were presented in Table 17. In the study area, about 62.34% and 37.66% in the mid and 73.83% and 26.17% in lower altitudes of respondents were providing water to their livestock from river and spring water, respectively. In the study district, the majority of the mid (72.45%) and low altitude area (89.88%) of the respondents practiced group watering system. This was reducing the qualities of water consumption and amount of daily livestock requirements. The average water consumption per animal unit (AU) was estimated at 48.9L/day increasing by 0.81 L/AU for each degree Celsius increase in maximum daily temperature (Ali *et al.*, 1994).

Improving water quality will allow animals to drink more, resulting in improved feed consumption and subsequently improved performance. Different study reported that livestock having access to clean water gain more weight than those consuming water from direct access to river. Willms *et al*. (2002) reported that a positive trend towards improved 20% greater weight gains cow drinking clean water compared with those animals with direct access to the water sources. It is important to determine the effects of water quality on animal performance so that appropriate management practice can be developed.

In the study district, livestock get water at an average distance of less than 1km. Getting water sources at the nearest distance can save their energy that is otherwise wasted in searching water. In the present study, 61.41 % of respondents water their livestock once a day and 38.59% of respondents twice a day. Endale (2015) reported in Meta Robi area, 38.9%, 52.2% and 7.8% of respondents watering their animal once in a day, twice in a day and *ad libitum*, respectively.

Table 17: Source of water, livestock watering system and frequency of watering of respondents in the study district (N=127)

Variable	Mid altitude	Low altitude	Over all mean
Source of water			
River	62.34%	73.83%	68.08%
Spring water	37.66%	26.17%	31.92%
Watering system			
Individual watering	18.72%	4.40%	11.56%
Group watering	72.45%	89.88%	81.17%
Both system	8.83%	5.72%	7.27%
Frequency of watering			
Once a day	58.28%	64.54%	61.41%
Twice a day	41.72%	35.46%	38.59%

4.3. Seasonal Availability of Feed Resources in Study Area

The seasonal availability feed resources in the study area are shown in Figure 1. In the study area, three feeding periods are identified and these periods have different characteristics. In the first period, during the main rainy season (May- November) feed resources are adequate both in quantity and qualities. Natural pastures and some stubble grazing are the main feed resources in the seasons. But later it become diminished and completely lost in dry season from November to April in early rainy season. Similarly, most authors recommend, feed supply from natural pasture fluctuates following seasonal dynamics of rainfall (Alemayehu, 1998; Solomon *et al*., 2008). 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 (Alemayehu, 2006). Given seasonal and weather-related variations, there are high temporal and spatial variations in the amount and quality of feed available from natural pastures (Senbeto *et al*., 2010). Therefore, the producers must known feed supply calendars and use conservation mechanisms.

In the study area, stubbles grazing like haricot bean, maize and teff are also the major feed resources following the cessation of the main rain season (November to December) in the study area. During this period, the amounts of feed and qualities feeds resources are progressively decreased. Tesfaye (2008) reported the shortage of feed begins from the end of November and the months of January, February and March are the driest months when the productivity of the natural pasture and fodder shrubs were dwindles.

Second period is dry period (in most cases from January to early in March), which characterized by feed supply from crop residues but poor in qualities. Crop residues like maize stover, sorghum straw, finger millet, teff straw, wheat straw, nug chuff ,haricot bean straw and barley straw were the major feed supply in the season. In this dry season the availability and quality of pasture reduced to such an extent that livestock may not fulfill the energy requirement to maintain their bodyweight. Then productivity the livestock was completely reduced. Ulfina *et al.* (2013) reported feed scarcity resulted in body weight loss and reduction of milk yield.

The third period is the late dry season especially from late March to April, the critical time for livestock when all feed resources completely utilized in the area. Only browse trees and non-conventional feeds are available to utilize these palatable and unpalatable species which inadequate supply in a season of the study area. Bisrat (2014) reported that feed shortage is common particularly during the latter part of the dry season (April to June) and at the start of rainy season at the time when crop residues are limited.

Feeding calendar is important for management and utilization of available feed resources in the study area. Silage making is not known and also hay making is not practiced in the study area. Relatively feed is in good supply during the months of June to September, during this period there is better growth of pasture, maize thinning and weeds grown in annual crops are available. Thus, the effective collection, conservation and proper utilization of crop residues and hay making might increase the quantity of available feed, and looking for other alternatives options such as use of urea treatments, nutrient block, silage making and scale-up of improved forage species with participatory approach will improve the nutritional quality of available feed for dry season in study area.

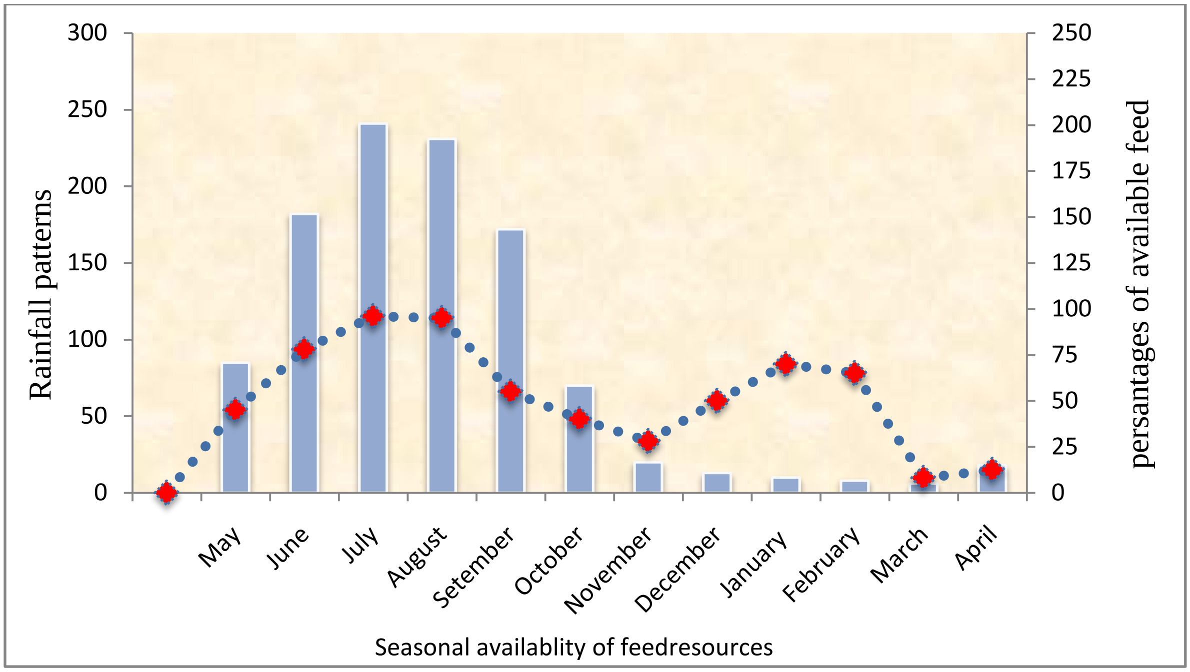

Figure 1: The seasonal availability feed resources in Lalo kile district

4.4. Evaluation of Livestock Feeding Systems

The evaluation of feeding system in the study area is shown in Figure 2. Depending on availability of feed in terms of type, quantity and quality, and physiological stage of the animal and production objectives farmers feed their livestock in different ways. Sometimes prevalence of tsetse fly also forces farmers to practice certain feeding strategies in the study area. The type of feeding is also influenced by the season of the year. In the study district, about 43.85%, 21.05%, 31.4% and 3.7% of respondents in wet season and 86%, 9.05, 0% and 4.95% of the respondents in dry season fed their animals in free grazing/browsing, tethering , split feeding, and cut and carrying, respectively. Bedasa (2012) reported that the feeding system practiced in Jeldu district was 94.5%, 4.4% and 1.1% of respondents feed their livestock's let to graze, cut and carry and tethering, respectively. Endale (2015) also identified indoor, group feeding, let to graze and tethering are the types livestock feeding practiced in Meta Robi of west Shewa zone.

In both agro ecologies of the study area, farmer practiced livestock feeding in split feeding (early in the morning and evening) due to lack of grazing land, prevalence of disease (trypanosomiasis by tsetse fly) and lack of labor in wet season. Thus, livestock graze between 6:00 am -9:00 am in morning and 3:00 pm - 7:00pm when they go back home, but there were significant differences

(P<0.05) in the length of grazing hours between both sites. The estimated average grazing hours in mid altitude and low altitude were 6:0±0.2 and 8:0±0.6 hours per day, respectively. Zewdie (2010) reported that the estimated average grazing hours in around Ziway were 6.8±0.5 and 10.0±0.1 hours per day, respectively.

During the dry season, farmers were providing crop residues to their livestock let to graze from the stacks or given small quantities in the morning and evening, and for working oxen, before and after work. The residues left in the threshing area consumed by livestock together with the standing straws which are left for aftermath grazing in the study area .In addition farmers provide fodder trees by climb up and cut the branches or use stick to shake down pods, leaves, flowers and fruits to feed their livestock. But unless this cutting is carefully regulated the trees were not regrown it will weaken and eventually kill the browses.

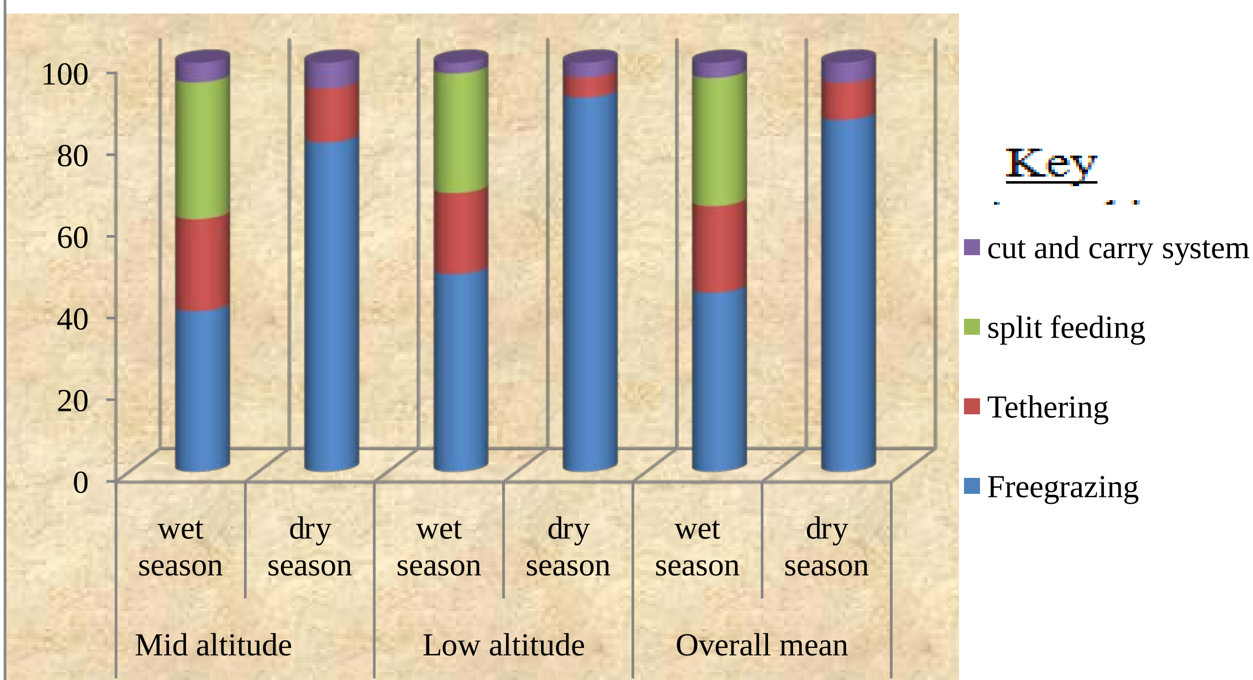

Figure 2: Livestock feeding systems in Lalo kile district

4.5. Chemical Composition and Nutritive Values of Feeds Resources

4.5.1. Effects of Species types and Agro ecologies on Chemical Composition of Natural Pastures

One of the basic needs in the planning and utilization of pastures and achieving optimum performance of livestock is determining the nutritional needs of livestock in terms of energy, protein, minerals and vitamins. This is only possible when the quality of pastures forage plants for each region in terms of chemical composition is known. Pastures forage quality varies with species and agro ecologies. Therefore, knowledge of forage quality in different regions and different climatic conditions should be considered for proper utilization of pastures.

The nutritional values of feed samples from natural pastures are presented in Table 18. The dry matter (DM) content of grasses and legumes are ranged from 88.2 % (*Vigna vexillata* L. A. Rich) to 91.7 % of (*Musa paradisiaca)* in mid altitude($p<0.05$) and 88.7% (*Vigna vexillata* L. A. Rich.) to 92.0% (*Musa paradisiaca*) in low altitude ($p<0.01$) of the study area. Grasses had more dry matter content than legumes species.

In wet season, the crude protein (CP) content of grass and legume species ranged from 9.1% (*Pennisetum sphocelatum)* to 19.1%*(Medicago burweed)* in mid altitude and 7.7% to 17.6% with similar feed in low altitude of study area. The CP composition was significant different ($p<0.01$) between species and agro ecologies. The variation in nutrient status of feeds was due to forage species and agro ecologies with different soil fertilities. The present result is in agreement with in the ranges of Deribe *et al*. (2013) who reported the CP contents of natural pasture was 1.42% to 18.95% in southern Ethiopia. The present results of crude protein contents of forage grasses and legumes were moderate in nutritional qualities in the study area.

The NDF contents of natural pastures in wet season was significantly different ($p<0.01$) between the two agro ecologies of the study area. The NDF contents of feed samples ranged from 22.9% to 66.9% in mid and 31.3% to 73.4% in low altitude respectively. This was due to the difference in agro ecologies. The highest NDF was found in *Pennisetum sphocelatum* and the lowest was found in *Vigna vexillata* L. A. Rich. The present result of NDF contents of natural pasture was similar within the ranges of Deribe *et al*. (2013) in southern Ethiopia.

The ADF contents of natural pasture feed also ranged from 26.80% to 56.47% in mid altitude and 23.40% to 62.0% in low altitude with significant different between species and agro ecologies ($p<0.01$). Thus the highest ADF was found in *Pennisetum sphocelatum* and the lowest was observed in *Vigna vexillata* L. A. Rich. The present result was agreement with in the ranges of Fekede *et al*. (2014) result at tropical highland of Ethiopia. The highest ADF was observed in grasses species than legumes species.

The metabolizable energy (ME) contents of natural pastures ranged from 7.3MJ *(Pennisetum clandustinum*) to 11.7MJ (*Vigna vexillata* L. A. Rich) in mid altitude and 3.4MJ (*Pennisetum purpureum* to 11.0MJ (*Vigna vexillata* L. A. Rich) in low altitude of the study area. The digestible crude protein (DCP) of feed samples in the study area was ranges from 4.9g to 14.2g and 3.6g to 12.8g in mid and low altitudes, respectively. The highest DCP was found in *Medicago burweed* and the lowest was in *Pennisetum sphocelatum* in the study area. The DCP was significant different at ($p<0.01$) between species and agro ecologies of the study area. The majority of feed samples from natural pasture possessed CP content in the study area. Fiber and protein are chemical fractions that have been most closely associated with intake and digestibility (Van Soest, 1994). The poor nutritive values of grasses and their lower degradability results in low intake and feed utilization, and thereby reduce performances of animals (Solomon *et al*., 2004).

Table 18: Chemical composition and nutritive values of major grasses and legumes in study area

Feedstuff	Chemical composition (% DM)									Nutritive values	
	DM (%)	OM	Ash	EE	CP	CF	NDF	ADF	NFE	DCP (g/kg DM)	ME(MJ/ kgDM)
Mid altitude area											
Pennisetum clandustinum	90.20[bc]	90.00[f]	10.00[a]	2.20[bc]	13.30[b]	44.20[c]	58.50[dc]	47.40[d]	18.40[d]	10.70[b]	7.30[e]
Digitaria abyssinica	90.40[ba]	90.90[e]	9.10[b]	2.60[a]	13.70[b]	36.00[e]	57.60[d]	46.07[d]	27.10[b]	11.10[b]	10.00[cb]
Pennisetum sphocelatum	91.80[a]	93.80[b]	6.20[e]	1.80[d]	9.10[e]	49.40[a]	66.90[a]	56.47[a]	25.30[cb]	4.90[e]	8.00[d]
Cymbopogon citrates DC.	90.80[ba]	94.00[ba]	6.00[fe]	1.30[e]	9.60[e]	50.30[a]	58.40[dc]	51.53[c]	23.60[c]	5.40[e]	7.80[ed]
Pennisetum purpureum	90.60[ba]	92.70[c]	7.30[d]	2.00[dc]	10.40[d]	46.80[b]	59.70[c]	50.20[c]	24.10[c]	6.10[d]	8.30[d]
Snowdine polystarch	90.70[ba]	94.50[a]	5.50[f]	2.00[dc]	11.60[c]	47.00[b]	59.50[c]	50.07[c]	23.60[c]	8.20[c]	8.30[d]
Medicago burweed	88.80[dc]	91.90[d]	8.10[c]	1.80[d]	19.10[a]	34.50[e]	37.10[e]	28.33[c]	25.30[cb]	14.20[a]	10.00[b]
Vigna vexillata L. A. Rich.	88.20[d]	93.80[ba]	6.20[fe]	2.20[bc]	13.60[b]	27.10[f]	32.90[f]	26.80[e]	37.10[a]	10.90[b]	11.70[a]
Musa paradisiacal	91.70[a]	90.20[f]	9.80[a]	2.40[ba]	11.40[c]	40.10[d]	64.20[b]	53.20[b]	27.00[b]	8.00[c]	9.40[c]
CV	0.93	0.43	5.27	8.93	3.03	2.27	2.35	2.50	6.21	4.20	4.09
p-value	<.0021	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001

Continues

Feedstuff	Chemical composition (% DM)									Nutritive values	
	DM (%)	OM	Ash	EE	CP	CF	NDF	ADF	NFE	DCP (g/kg DM)	ME(MJ /kg DM)
Low altitude area											
Pennisetum clandustinum	90.80[b]	91.20[f]	8.80[b]	1.60[cd]	12.00[c]	50.10[c]	65.70[c]	54.40[d]	16.20[g]	9.50[c]	6.20[ef]
Digitaria abyssinica	90.20[b]	92.10[e]	8.00[c]	1.90[cb]	11.40[d]	41.00[e]	62.40[d]	51.07[e]	25.90[b]	9.00[d]	9.20[b]
Pennisetum sphocelatum	90.30[b]	95.40[a]	4.60[g]	2.20[b]	7.70[h]	54.70[b]	73.40[a]	62.00[a]	21.10[dc]	3.60[h]	6.70[ed]
Cymbopogon citrates DC.	90.30[b]	92.80[d]	7.20[d]	0.80[e]	8.60[g]	56.50[ba]	67.50[c]	56.13[c]	17.30[fg]	4.40[g]	5.60[f]
Pennisetum purpureum	90.70[b]	91.80[fe]	8.20[cb]	1.60[cd]	12.70[e]	57.40[a]	67.70[c]	57.00[c]	10.80[h]	8.30[e]	3.40[g]
Snowdine polystarch	90.60[b]	93.90[cb]	6.10[fe]	1.50[d]	10.40[f]	51.70[c]	63.30[d]	50.47[e]	19.90[de]	7.10[f]	6.80[d]
Medicago burweed	89.30[c]	93.70[c]	6.30[e]	1.60[cd]	17.60[a]	41.80[e]	35.60[e]	25.87[f]	22.00[c]	12.80[a]	8.60[b]
Vigna vexillata L. A. Rich.	88.70[c]	94.50[b]	5.50[f]	1.90[cbd]	12.20[c]	30.10[f]	31.30[f]	23.40[g]	37.10[a]	9.70[c]	11.00[a]
Musa paradisiacal	92.00[a]	89.60[g]	10.40[a]	2.80[a]	13.10[b]	44.70[d]	70.10[b]	59.60[b]	19.00[fe]	10.50[b]	7.60[c]
CV	0.44	0.48	6.22	12.81	1.56	2.24	2.31	2.12	5.52	2.22	4.78
p-value	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001

Note: DM=Dry matter; OM =Organic Matter; CP = Crude Protein; NDF=Neutral Detergent Fiber; ADF= Acid Detergent Fiber; NFE = Nitrogen Free Extract, DCP=Digestible Crude Protein; ME= Metabolizable Energy

4.5.2. Chemical Composition of Crop Residues

Chemical compositions and nutritive values of the common feedstuffs in the study area are shown in Table 19. The dry matter (DM) content of all crop residues was above 90% in both agro ecologies of the study area. The present result was agreed with Zewdie *et al*. (2011) and Solomon *et al.* (2008). The DM content of crop residues was significant different (p<0.05) with in altitude of the study district. This might be due to crop types and climate difference. The crude protein (CP) content of crop residues varied from 3.95% in wheat straw to 9.19% in nug chuff mid altitude area and 3.94% of sorghum to 6.72% of haricot bean crop residues in low altitude area. The CP content of feed samples was similar with Deribe *et al.* (2013) reports ranges from 2.01-8.97% at southern Ethiopia. The crude protein content of crop residues was significant different (p<0.01) between feed sample in both agro ecologies of the study district. This might be related to plant species and climate difference in the study area. Lower CP value for wheat straw reported in this study agrees with the reports of Bisrat (2014) which 3.03% CP content of wheat straw at Dera district, south Gondar. Except nug chuff, all crop residues evaluated had lower CP contents than the minimum level of 7% CP required for optimum rumen microbial function in study area.

The neutral detergent fiber (NDF) content of all crop residues was above 65% except noug chuff (57.53%) in the both agro ecologies of the study area. Solomon *et al*. (2008) reported that all crop residues had higher than (> 70%) NDF contents with similar study in Sinana sub district of Bale highland. Roughage feeds with NDF content of less than 45% are categorized as high quality, 45-65% as medium quality and those with more than 65% as low quality roughages (Sigh and Ousting, 1992). All crop residues in this study were categorized as low quality roughages and their high cell wall content can be a limiting factor to feed intake. As DM intake and NDF content are negatively correlated (Ensminger *et al.*, 1990) that may impose limitations on livestock performance.

The acid detergent fiber (ADF) values obtained from crop residues in this study was significantly different (p<0.01) in both agro ecologies. The ADF content of all crop residues was above 50% in both agro ecologies of the study area (Table 19). The result was agreement with the ranges of Zewdie (2010) reports of wheat straw, haricot bean and maize stover values of ADF at central rift valley of Ethiopia. Generally, Kellems and Church (1998) categorized roughages with less than 40% ADF as high quality and those above 40% as low quality. All crop residues could be categorized as low quality roughages in the study district.

The energy contents and digestible crude protein of crop residues was significantly different ($p<0.01$) between both agro ecologies. The energy content of crop residues ranged from 8.77 MJ (nug chuff) to 9.50MJ (maize stover) in mid altitude and 8.99MJ (sorghum) to 11.13MJ (haricot bean) straw in low altitude area of the study district. The energy contents for crop residues in this study were within the range reported by Seyoum and Fekede (2008) in West shewa zone of Ethiopia, but higher than the value of 7.9 MJ DM reported by Zewdie (2010) in peri-urban areas of Ethiopia. Differences might be due to differences in soil fertility and crop variety used. The digestible CP contents of crop residues varies from 0.15g (wheat straw) to 5.02 g (nug chuff) in mid altitude and 0.14g (sorghum) to 2.32g (haricot bean) in low altitude area. The result was disagreement with Zewdie (2010)who reported the lowest energy content crop residues was 6.48MJ of wheat straw to 7.89MJ barley straw and the DCP contents 24.85g of oats straw to 59.04g of haricot bean at central rift valley of Ethiopia. Seyoum *et al*. (2007) proposed a standard for energy and protein as those feeds, which contain CP 67g and ME (13.1 MJ). The present result of the energy and protein content of crop residue were lower than the reported thresholds. This was due to climatic difference and post harvest handling of the crop residues in the study area.

Table 19: Chemical composition and nutritive values of major crop residues in the study area

Feedstuff	Chemical composition (% DM)									Nutritive values	
	DM (%)	OM	Ash	EE	CP	CF	NDF	ADF	NFE	DCP (g/kgDM)	ME (MJ/kg DM)
Mid altitude area											
Teff straw	92.47^{cb}	95.60^{b}	4.40^{e}	1.20^{cbd}	4.43^{c}	53.46^{b}	68.60^{a}	57.80^{b}	35.55^{a}	0.65^{c}	8.89^{bc}
Finger millet	91.53^{cbd}	91.83^{e}	8.17^{b}	1.10^{d}	4.09^{d}	52.76^{c}	67.40^{ba}	55.47^{c}	31.00^{c}	0.28^{d}	8.80^{dc}
Wheat straw	92.67^{b}	94.00^{d}	6.00^{c}	1.27^{cb}	3.95^{d}	57.76^{a}	70.07^{a}	60.40^{a}	33.41^{b}	0.15^{e}	8.72^{dc}
Maize stover	90.23^{d}	94.87^{c}	5.13^{d}	1.17^{cd}	4.47^{c}	47.89^{e}	65.47^{b}	55.07^{c}	35.03^{ba}	0.67^{c}	9.42^{a}
Sorghum stover	91.30^{cd}	97.13^{a}	2.87^{f}	1.33^{b}	5.98^{b}	51.80^{de}	65.60^{b}	54.33^{c}	35.54^{a}	2.04^{b}	9.08^{ba}
Noug chuff	94.63^{a}	89.83^{f}	10.17^{a}	3.53^{a}	9.19^{a}	51.90^{d}	57.53^{c}	49.80^{d}	25.90^{d}	5.02^{a}	8.62^{d}
CV	0.80	0.23	3.57	4.97	1.88	1.10	2.29	1.64	3.31	2.92	1.38
p-value	<.0012	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	< .0001	<.0013
Low altitude area											
Finger millet	90.77^{b}	94.90^{b}	5.10^{b}	1.73^{b}	4.81^{b}	62.04^{a}	68.53^{cb}	54.33^{c}	37.12^{a}	0.95^{b}	9.48^{b}
Sorghum stover	92.33^{a}	95.13^{b}	4.87^{b}	1.53^{cb}	3.94^{c}	57.53^{b}	67.33^{c}	56.27^{b}	34.72^{b}	0.14^{c}	8.76^{b}
Maize stover	91.87^{ba}	95.67^{a}	4.33^{c}	1.40^{c}	4.04^{c}	56.04^{c}	69.93^{b}	57.47^{b}	36.16^{a}	0.31^{c}	8.95^{b}
Haricot bean	92.38^{a}	93.94^{c}	6.06^{a}	2.30^{a}	6.72^{a}	49.20^{d}	73.02^{a}	62.30^{a}	28.20^{c}	2.32^{a}	11.13^{a}
CV	0.72	0.21	3.96	6.25	6.19	0.65	1.02	1.22	2.22	14.58	5.81
p-value	<.16	<.0007	<.0007	<.0006	<.0003	<.0001	<.0007	<.0001	<.0001	<.0001	<.018

Note: DM=Dry matter; OM =Organic Matter; CP = Crude Protein; NDF=Neutral Detergent Fiber; ADF= Acid Detergent Fiber; NFE= Nitrogen Free Extract DCP=Digestible Crude Protein; ME= Metabolizable Energy.

4.5.3. Chemical composition of Shrubs and Fodder Trees

The chemical composition of different edible parts (leaf, root, shoot and pod) fodder tree and shrub species in the study area is presented in Table 20. The dry matter contents of shrubs and fodder trees are above 88.63% in mid and 87.83% in low altitude of the study district. The result was relatively similar with the result of Abebe *et al.* (2008) who reported the dry matter contents of multipurpose fodder trees was within range of 89.4-93.1% in Lay-Armachuho and Sidama district of the Ethiopian. Fodder trees and shrubs had CP content ranging from 8.9% (*Zehneria scara)* root to 23% (*Sapium ellipticum*) leaves in mid and 6.27% (*Schefflera abyssinica)* to 18.24% (*Myrsine africana L.*) in low altitude of the study district. The present study of CP contents for shrubs and fodder trees was comparable within range of Belete *et al.* (2012) report the CP contents of tree and shrubs ranging from 8.9% to 20.9%. The high CP content of browse species makes them a potential source protein supplement for feeds of poor quality roughages and forages.

The lowest NDF content (40.60%) observed for *Cucumis ficifolius* A. Rich (40.60%) and the highest (55.60%) was for *Ficus sur* Fossk in mid and *Myrsine africana* L. (43.80%) was the lowest and *Schefflera abyssinica* (59.2%) was the highest observed in low altitude of the study area. The NDF values for the current feeds analysis are comparable with that reported by Takele *et al.* (2014) at the districts of Wolayta zone, southern Ethiopia. Similarly, the ADF content varied from 26.93% (*Cucumis ficifolius* A. Rich) to 47.6% (*Ficus ovata*) in mid altitude and 34.60% (*Myrsine africana* L.) to 52.67% (*Schefflera abyssinica*) in low altitude area. The high ADF content in shrubs and fodder trees associated with lower digestibility since digestibility of feed. The highest and lowest ME content was found in *Ficus sur Fossk* (12.77 MJ) and *Alb*izia *gumifera* (7.88MJ) in mid and *Myrsine africana* L (12.30 MJ) and *Bersama abyssinica* (8.66MJ) in low altitude of study area. The ME values of current study was greater than the reports of Diriba *et al*. (2013) in Sub humid areas of Western Ethiopia. The DCP contents of shrubs and fodder trees were varies from *Zehneria scara* (4.75g) to *Sapium ellipticum* (28.02g) mid and *Schefflera abyssinica* (2.31g) to *Myrsine africana* L (13.42g) in low altitude of the study area. The low contents of nutritive of fodder trees are normally characterized by low digestibility and low energy values results reduce livestock performances.

Table 20: Chemical composition and nutritive values of fodder trees and shrubs in mid altitude area

Feedstuff	Chemical composition (% DM)									Nutritive values	
	DM (%)	OM	Ash	EE	CP	CF	NDF	ADF	NFE	DCP (g/kg DM)	ME (MJ/kg DM)
Rubus apetalus Poir	90.57[bdc]	91.50[ef]	8.50[cd]	1.17[h]	14.59[d]	32.49[d]	41.28[f]	32.73[f]	33.60[c]	10.12[d]	10.81[e]
Vernonai amygadalina	91.23[ba]	91.97[d]	8.03[c]	3.53[b]	17.80[c]	31.53[d]	41.80[fe]	32.60[f]	30.09[e]	13.11[c]	10.83[e]
Rhoicissus tridentate	90.43[dc]	91.00[g]	9.00[b]	1.77[g]	17.80[c]	28.16[e]	51.93b[c]	44.27[b]	33.49[d]	13.11[c]	11.39[c]
Cucumis ficifolius A.	88.63[f]	90.93[g]	9.07[b]	1.20[h]	14.44[d]	35.07[c]	40.60[f]	26.93[g]	28.57[f]	9.90[e]	10.26[g]
Albizia gumifera	89.97[ed]	91.20[gf]	8.80[cb]	2.00[f]	9.34[g]	47.27[a]	50.20[c]	37.07[d]	22.32[h]	5.25[h]	7.88[i]
Ficus sur Fossk	89.23[ef]	91.83[ed]	8.17[ed]	2.53[e]	13.23[f]	16.38[g]	55.60[a]	47.07[a]	49.30[a]	8.71[g]	12.77[a]
Ficus ovate	88.83[f]	93.80[c]	6.20[f]	2.40[e]	18.38[b]	38.80[b]	53.67[ba]	47.60[a]	23.12[h]	13.65[b]	9.17[h]
Sapium ellipticum	90.77[bc]	96.83[a]	3.17[h]	3.23[c]	23.85[a]	24.11[f]	43.87[e]	34.40[e]	26.58[g]	28.02[a]	11.57[b]
Combertum paniculatum	91.53[a]	95.25[b]	4.75[g]	3.80[a]	13.72[e]	29.09[e]	51.27[c]	43.20[b]	39.78[b]	9.31[f]	11.16[d]
Zehneria scara	91.00[bac]	89.83[h]	10.17[a]	2.70[d]	8.90[h]	34.02[c]	47.20[d]	41.27[c]	35.06[c]	4.75[i]	10.60[f]
CV	0.48	0.22	2.80	3.47	1.00	1.92	2.52	2.32	2.61	0.56	0.83
p-value	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001

DM=Dry matter; OM=Organic Matter; CP = Crude Protein; NDF=Neutral Detergent Fiber; ADF= Acid Detergent Fiber; NFE= Nitrogen Free Extract DCP=Digestible Crude Protein; ME, Metabolizable Energy.

Table 21: Chemical composition and nutritive values of fodder trees and shrubs in the Low altitude area

Feedstuff	Chemical composition (% DM)									Nutritive values	
	DM %	OM	Ash	EE	CP	CF	NDF	ADF	NFE	DCP (g/kg DM)	ME (MJ/kg DM)
Myrsine africana L.	89.70^{e}	88.10^{g}	11.90^{a}	3.20^{c}	18.24^{a}	21.53^{f}	43.80^{e}	34.60^{e}	34.63^{b}	13.42^{a}	12.30^{a}
Acanthus polystachius	90.87^{dc}	91.63^{d}	8.37^{d}	4.00^{a}	13.57^{c}	28.38^{e}	45.87^{d}	38.60^{d}	37.04^{a}	9.09^{b}	11.34^{b}
Combretum collinum	90.50^{d}	91.10^{e}	8.90^{c}	1.97^{d}	10.60^{d}	35.16^{d}	57.40^{b}	48.40^{b}	33.87^{b}	6.36^{c}	10.44^{c}
Ficus thonningii Blume	89.37^{e}	93.57^{c}	6.43^{e}	1.93^{d}	13.81^{b}	40.73^{b}	59.00^{ba}	49.67^{b}	26.76^{d}	9.25^{b}	9.35^{e}
Mcraceae (family name)	87.83^{f}	89.10^{f}	10.90^{b}	3.50^{b}	9.48^{e}	37.24^{c}	58.13^{ba}	51.40^{a}	27.04^{d}	5.25^{d}	9.85^{d}
Schefflera abyssinica	91.10^{c}	97.00^{b}	3.00^{f}	1.27^{e}	6.27^{h}	48.00^{a}	59.20^{a}	52.67^{a}	32.23^{c}	2.31^{g}	8.67^{f}
Bersama abyssinica	92.27^{b}	96.80^{b}	3.20^{f}	1.30^{e}	7.34^{f}	48.11^{a}	58.07^{ba}	48.60^{b}	32.44^{c}	3.32^{e}	8.66^{f}
Teclea nobilis	93.07^{a}	97.40^{a}	2.60^{g}	1.07^{f}	7.05^{g}	47.89^{a}	52.87^{c}	42.60^{c}	34.93^{b}	3.05^{f}	8.71^{f}
CV	0.23	0.16	2.15	3.05	1.21	1.66	1.88	2.03	1.98	1.46	0.94
p-value	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001

DM=Dry matter; OM=Organic Matter; CP = Crude Protein; NDF=Neutral Detergent Fiber; ADF= Acid Detergent Fiber; NFE, Nitrogen Free Extract DCP=Digestible Crude Protein; ME, Metabolizable Energy.

4.6. Estimation of Balance between Feed Supply and Requirements

4.6.1. Estimated Annual Available Feed Supply in the Study Area

The quantity of feed resource available in the study area was estimated using the data collected from the household respondents. The estimated amount of feed available by categories for maintenance of the total livestock population for each household is presented in Table 22. In terms of annual DM production per household, the available feed resources could be arranged as natural pasture (private grazing land, communal grazing and fallow land), roadside grazing, crop residues, stubble crops, fodder trees and shrubs, non-conventional and improved forages sequentially in the study area.

The annual total utilizable feed supply was 12.58±0.22 and 11.17±0.46 tons of DM per household year in mid and low altitudes of the study area, respectively. The annual utilizable DM feed supply per household varied between the two agro-ecologies as compare to total tropical livestock unit. Of the total supply feed resources, crop residues (4.1±0.11 tons) and natural pastures (3.96± 0.12tons) were found to be the largest contributors of DM yield per year per household in both altitudes of the study area. The contribution of foliages of fodder trees and shrubs to total feed supply was estimated to be 1.83± 0.01tons of DM. Other less available feed resources such as stubble crops, roadsides and non-conventional feed, improved forages and supplementation estimated from the daily feed allocation data provide about 1.97±0.07tons of DM per year. But some of dry matter requirement of weed and supplementary feed are not included in the estimation because of lack of conversion factors. The overall total DM obtainable from the major and minor available feed resources in the study area was estimated to be 11.87±0.62 tons TDM per year per household in study district. This result was similar with Dawit *et al.* (2013) who reported total DM available 11.72tons per household in Adami Tullu Jiddo Kombolcha District, Ethiopia.

The digestible crude protein and metabolizable energy available per household in the study area is shown in Table 22. Hence, nutrient requirements per TLU were calculated for the two major requirements; that is DP and ME. The average supply of digestible crude protein and metabolizable energy per household per year were estimated to be 120.81kg, 79254MJ in mid and 116.41kg, 70371 MJ in low altitude, respectively. However, in the current study the quality of the available feeds were found to be very poor as the feeds contain high fiber and, as a result, unable to supply the required amount of protein and energy for the animals. The present result was lower supply than the finding of Zewdie (2010) who reported 21.3t, 725.4kg and 146,393MJ of TDM, DCP and ME per household per year, respectively around Ziway, central rift valley of Ethiopia. The difference might be due to different land holding conditions and feed qualities.

Table 22: Estimated available mean dry matter production (ton), ME (MJ) and DCP (kg) per household per annual feed resources categories according to agro-ecological differences (N= 127)

Feed resources	Mid altitude (N=66)			Low altitude (N=61)			Overall mean(N=127)		
	TDM	TME	DCP	TDM	TME	DCP	TDM	TME	DCP
Natural pasture	4.61 ±0.03	29043	54.05	3.32±0.18	20916	34.69	3.965±0.12	24979.5	44.37
Roadside	0.47± 0.01	2961	5.52	0.21±0.02	1323	2.19	0.34±0.01	2142	3.85
Crop residue	4.42± 0.10	27846	22.10	3.78±0.19	23814	28.35	4.1± 0.11	25830	25.22
Stubble crop	1.01 ± 0.03	6363	8.08	0.92±0.05	5796	7.36	0.96±0.03	6048	7.72
Non-conventional	0.30± 0.01	1890	3.15	0.73±0.06	4599	7.30	0.52±0.04	3276	5.23
Tree and shrubs	1.56± 0.01	9828	24.34	2.10±0.02	13230	34.65	1.83 ±0.01	11529	29.50
Improved forages	0.21± 0.04	1323	3.57	0.11±0.02	693	1.87	0.16±0.03	1008	2.72
Total	12.58±0.22	79254	120.81	11.17±0.50	70371	116.41	11.875±0.56	74812.5	118.61

TDM=Total Dry matter; TME=Total Metabolizable Energy; DCP=Digestible Crude Protein; N=Number of households

4.6.2. Annual Estimated Dry matter, Digestible Crude protein and Metabolizable Energy Requirements

The estimated amount of maintenance requirements of feed nutrients to the total livestock population for the 127 household is presented in Table 23. The amount of feed ingested, digested and metabolized by animals is used for maintenance and production (growth, work and reproduction). The amount of DM, ME and DCP required by given TLU were calculated based on required per TLU per day and converted into requirement of the total livestock biomass per year.

The DM maintenance requirements of the livestock population are estimated according to the daily DM requirements for maintenance of one TLU (250kg livestock consume 2.5% of its body weight which was 6.25kg DM/day/animal or 2281kg/year/animal (Kearl L.C., 1982). The digestible crude protein requirement for maintenance was 160g digestible protein per day (FAO, 1986) for one tropical livestock unit. The average energy maintenance requirement of one tropical livestock unit was calculated according to King (1983) which was 29.84MJ/TLU.

Accordingly the yearly total dry matter, digestible crude protein and metabolizable energy maintenance requirements for the indicated livestock population was estimated 16.22±1.1t, 415.22kg , 77439.3MJ in mid and 19.69±1.9t, 503.99kg, 93994.5MJ in low altitude area with overall 17.95±1.5t, 459.61kg and 85716.9MJ per household per year, respectively. From this result, the total dry matter requirement in the low altitude was higher than mid altitude. This is due to relatively large number of livestock in low altitudes.

Table 23: Estimated dry matter, digestible crude protein and metabolizable energy annual maintenance requirements for tropical livestock unit

Variables	TLU	Daily requirements/TLU	Annual requirements/HH
Mid altitude			
TDM	7.11±0.61	6.25kg	16.22±1.1ton
DCP	7.11±0.61	160g	415.22kg
ME	7.11±0.61	29.84MJ	77439.3MJ
Low altitude			
TDM	8.63±1.08	6.25kg	19.69±1.9ton
DCP	8.63±1.08	160g	503.99kg
ME	8.63±1.08	29.84MJ	93994.5MJ
Overall mean			
TDM	7.87±0.84	6.25kg	17.95±1.5ton
DCP	7.87±0.84	160g	459.61kg
ME	7.87±0.84	29.84MJ	85716.9MJ

TLU=Tropical Livestock Unit; DCP=Digestible Crude protein; ME=Metabolizable Energy; HH=Household

4.6.3. Estimated Annual Feed Balance between Supply and Requirements

The total annual available nutrient, nutrient requirements for maintenance and feed balances is shown in Table 24. The difference between dry matter available and required was measured by balancing the amount of feed required by the total livestock population and the amount of feed supplied. In the mid altitude area, the estimated available feed supply met about 77.56% of the TDM maintenance requirements of livestock per household per year. While the total estimated DCP and ME were 29.10% and 102.34% per year per household. In the low altitude area, only 56.73% of total DM meets the total livestock requirement per annum per household. In the same way, the total yearly available DCP and ME cover only 23.10% and 74.86% of the total livestock requirement supplies per household, respectively. Therefore, the total dry matter production, digestible crude protein and metabolizable energy supply was only met 9, 3.5, 12 months in mid and 7, 3 and 9 months in low altitude of the study area, respectively. In the rest of the months, livestock suffer from feed shortage. The larger deficit observed under low altitude area was associated with poor nutritive value of the major feeds resources in relation to the greater number of livestock population in the area.

As overall the annual feed available on a year round base meets only 66.13%, 25.81% and 87.28% of the DM, DCP and ME total requirements per household in study district, respectively. Negative balance of DM requirement, total DCP and ME observed in the current study was similar with Zewdie (2010) reported 66.4%, 36.5% and 67.2%, respectively around Ziway, central rift valley of Ethiopia. Contrastingly surplus DM supply than the total annual livestock requirement in North Gondar (Sisay, 2006) and the nutrient balance in the DM supply of the feed in Metema district is sufficient to support the livestock per household (Tesfaye, 2008). These positive values reported might be related to the small livestock population in the area and also the fertility of the land favoring feed production.

Hence both energy and protein are the major limiting factors for livestock productivity (McDonald et al., 2010); adequate energy must be supplied by the diet to make efficient use of dietary protein. The protein requirements of animals are given in terms of an amount of protein and its constituent amino acids per unit of time - usually the amount to be fed each day. The decreasing status of livestock against epidemic diseases could be referred to low supply of dietary proteins reflected on the immune response. The utilization of dietary proteins (Bakrie *et al*., 1996) must be put in the context of the available energy supply. If energy is limiting dietary protein will be used inefficiently as another source of energy instead of being converted into body protein. However, the present study confirmed that protein was the most lacking nutrients especially for the dry season feed resources in both agro ecologies. Accordingly, a feed shortage notwithstanding, considerable potential exists to increase production levels across the range of improving livestock performance might be by addressing the problem of imbalanced nutrition. Imbalanced feeding could also leads to excess feeding of some nutrients whilst others remain deficient. This not only reduces productivity and increases costs per kg product, but also affects various physiological functions including long term animal health, fertility and productivity.

Table 24: Average estimated annual TDM (tons), ME (MJ) and DCP (kg) available, demand and balance per household for maintenances tropical livestock unit in the study area

Agro-ecologies	N	TLU	Annual nutrient available			Annual nutrient demand			Annual nutrient balance		
			TDM	TME	DCP	TDM	TME	DCP	TDM	TME	DCP
Midland	66	7.11±0.61	12.58±0.22	79254	120.81	16.22±1.10	77439.30	415.22	-3.64±0.60	+1814.70	-294.41
									77.56%	102.34%	29.10%
Lowland	61	8.63±1.08	11.17±0.50	70371	116.41	19.69±1.90	93994.50	503.99	-8.52±1.10	-23623.50	-387.58
									56.73%	74.86%	23.10%
Average	127	7.87±0.84	11.87±0.56	74812.5	118.61	17.95±1.50	85716.90	459.61	-6.08±0.50	-10904.40	-341.00
									66.13%	87.28%	25.81%

TLU=Tropical Livestock Unit; TDM=Total Dry matter; TME=Total Metabolizable Energy; DCP=Digestible Crude Protein; N=Number of households

4.7. Constraints and Opportunities of Livestock Production in Relation to Feed Resources

4.7.1. Production and Reproduction constraints

In the study area, seasonal variations in feed quantity and quality is the main restriction to animal production and cause vacillation in productivity throughout the year, particularly in the dry seasons during which feed is scarce and poor in nutritive value. Feed supply shortages are root causes for poor performance of the livestock in the study area. It leads to slow growth rate in growing animals and low production and reproduction performance (Adugna, 2008). Farmers reported a decline in production and productivity and disease problem mainly trypanosomiasis. But the performance parameters like milk yield, age at first calving, calving interval and age at first drought are significant differences between agro ecologies ($p<0.05$) of the surveyed household. This might be related to the variable feed quantity and quality available in the area. Many studies confirm that feed shortage is a major cause of the low productivity of livestock (Alemayehu, 2002; Alemayehu and Sisay, 2003; Zegeye, 2003; Tilahun *et al*., 2005 and Belay *et al*., 2012).

The production parameters of sheep, goats, donkey, horse and mule were significant differences ($p<0.05$) between both agro ecologies of the study district. This might indicated unambiguous adaptation of livestock to feed shortage in terms of quantity and quality. Given their poor nutritional status, animals tend to be underweight thus producing little meat and achieving low prices when sold as live animals. It has also known that the estimated values of feed DM, CP and ME supply could not yet satisfy the normal maintenance requirements of livestock.

Livestock feeding calendar is an essential livestock management practice to use the available feed resources efficiently and to supply the livestock with required quantity and quality feed and to overcome feed shortage. Thus, when there is feed scarcity but the respondents taken measurements to alleviate feed shortage in ranked, storing the feed during available, completely reduce livestock numbers and encourage the use private grazing land in the area. Gezu *et al*. (2014) reported that feed scarcity was resolved mostly by storing the feed during available, using browse trees and traveling long distance for search feed, purchasing feed supplement, hay making and destocking in Lemo and Soro district of southern Ethiopia.

Table 25: Production and reproductive performance of livestock related to feed in mid altitude and low altitude areas of the study sites

Livestock species	Production parameters	Altitude of area		Overall		
		Midland (N=66)	Lowland(N=61)	Mean	SEM	*p-value*
	Average daily milk yield(lit/day)	1.82	1.47	1.65	0.015	<.0006
Cattle	Total lactation milk yield(lit/year)	318.77	257.33	288.05	1.72	<.0001
	Age at first calving(month)	54.11	55.77	54.94	0.63	<.0044
	Calving interval(month)	18.33	21.22	19.77	0.46	<.0016
	Lactation length(month)	5.88	5.55	5.72	0.66	<.8346
	Day open(day)	170.00	188.88	179.44	6.42	<.2593
	Number of services per conc.(trial)	1.88	2.44	2.16	0.52	<.1315
	Reproductive life span(year)	9.88	7.88	8.88	0.85	<.0249
	Draught age(year)	3.92	4.24	4.08	0.20	<.0097
	Draught life span(year)	6.11	5.00	5.55	0.79	<.1315
Sheep	Age at first lambing(month)	30.00	32.33	31.16	0.99	<.0011
	Lambing interval(month)	12.11	14.88	13.49	0.85	<.0097
	Age of slaughter(month)	24.11	28.00	26.05	0.89	<.0459

Significant different at ($p<0.1$) and non-significant different at ($p>0.1$)

Continues

Livestock species	Production parameters	Altitude of area		Overall		
		Midland (N=66)	Lowland(N=61)	Mean	SEM	*p-value*
Goats	Age at first kidding(month)	28.88	26.33	27.60	0.72	<.0066
	Kidding interval(month)	13.33	12.11	12.72	0.81	<.5787
	Age of slaughter(month)	28.88	26.00	27.44	1.12	<.0629
Donkey	Age at first foaling(month)	56.00	60.00	58.00	0.0	<.0001
	Age at first working(month)	60.00	62.00	61.00	0.0	<.0001
Horse	Age at first foaling(month)	53.33	59.55	56.44	1.38	<.0065
	Foaling interval(month)	24.22	25.00	24.61	0.81	<.5927
	Age at first working(month)	52.11	58.00	55.05	0.28	<.0001
Mule	Age at first working(month)	52.00	54.00	53.00	0.00	<.0001

Significant different at ($p<0.1$) and non-significant different at ($p>0.1$)

4.7.2. Efficiently Utilization of Feed Resources

Utilization efficiency had great problems to the available feed resources in the study area. Especially for crop residues, less attention given to storage, excessively dumped during harvest period, excessive sun shine, house construction and way of feeding are some of the problems in both agro ecologies of the study district. On other hand, the major uses of crop residues in the district is of course as a feed value but considerable households surveyed alternatively use crop residues for fuel, roof shatter, fences and any of their combinations as the need arises and this puts maximum pressure on the dry matter yield obtained from crop residues besides of failure to collect, store, treat and conserve it properly. This might be attributed to less attention given to post harvest management of crop residues. Yisehak and Janssens (2014) reported that shortage of feeds for livestock utilization problem contributes to more than 30% loss in Gilgel Gibe catchment of Ethiopia. Traditionally farmers had to developed not only storage and minor quality improvements but also had to reach a level where they could formulate their own ration from mixes of crop residues, indigenous browse and a non-conventional feed supplements hence crop residues and stubble could constitute the major feed in dry season for the area.

In wet season, grazing lands are overgrazed in small plot of lands during the time when crops are planted from April to September and indigenous browses are rarely lopped down for animals as feeds. Yeshitila (2008) reported that on top of shortages of feeds for livestock utilization problem contributes to more than 20% loss in Alaba district of southern Ethiopia. When feed resources are surplus silage making and hay making was also not practiced in the area. In other way, the quantity and quality of feed obtainable from natural pastures declines as the dry season progresses. The protein content and digestibility of most grass species decline rapidly with advancing physiological maturity of the plants and reaches very low levels during the dry season. Low digestibility associated with low nitrogen content of the feed limits intake and animals on these diets are often in negative energy and nitrogen balance.

Enhance the efficient utilization of feed resources also has to take into account the combined knowledge post harvest managements, packages of storages, preservation area, processing and improvement in feed quality. There are different techniques by which the quality of a feed could be improved by physical treatments a simple soaking with water, chopping, grinding and pelleting and chemical treatments, especially the latter improves the nutritive value of crop residues. Farmers respond that to alleviate feed shortage, enhance to storing the feed during available in a form of silage and hay preservation as the possible solution in the area.

4.7.3. Other constraints

The other constraints related to feed resources were shortage of grazing land, land degradation and low biomass yield, low quality and variable of feed across the season, weak adoption of improved forage production, shortage of family labor, poor access to feed market and poor extension service in both agro ecologies the study district. These result was agrees with the reports of Bedasa (2012) in highland of Blue Nile Basin of Ethiopia. Nutritional problems like bloating and diseases are other contributing factors affecting livestock production.

Enhance farmers use of intensification feed production (adopt different improved forage developments strategies), improve feed quality through ration formulation available feed resources and encourage the extension services are the opportunity to farmers uses to alleviate feed shortages in the area.

Ethiopia has an immense ecological diversity and a huge wealth of biological resources are an opportunities of livestock production. Similarly in the study area, the complex topography coupled with environmental heterogeneity offers suitable environments for a wide range of life forms, like variety of pasture species of herbaceous grass and legumes, shrubs and fodder trees, and different cultivated crops for supply of crop residues.

Integration of pasture and forage into farming systems also best opportunities for farmers to use land efficiency will be through the introduction of pasture and forages in the farming system. Seed production systems adopted in the country are farmer seed production system, seed production on ranches, seed production on specialized plot and opportunistic seed production. This provides a good opportunity for the farmers to establish local seed production in the existing farming system.

The irrigation potential of the study area is good, this is a good opportunity to grow off-season pasture and forage crops. In the country the potential of for irrigation is untapped and still there is a great opportunity for producing seasonal and long term irrigated pasture and forages (Alemayehu, 2006).

5. SUMMARY, CONCLUSION AND RECOMMENDATION

5.1. Summary and Conclusion

The study was carried out in Lalo kile district, Kellem Wollega Zone of western Ethiopia to identify the available feed resources in terms of types, quantity and quality both in during wet and dry season, evaluating livestock feeding systems, estimate annual feed produced, livestock nutrient for maintenance requirements, annual feed balance, and constraints and opportunities of livestock production in relation to feed resources available. The district was stratified in mid and low altitudes to collect primary data. Structured interview questionnaires were prepared to collect brief information from the sample households. The feed samples were collected from both altitudes during dry and wet seasons to analyzed and their chemical composition and nutritive values were determined.

In the study area, major feed available were natural pasture (36.0%), crop residues (34.49%), fodder trees and shrubs (15.60%), Stubble crops (8.13%), non-conventional feed (4.46%), improved forage in very limited (1.32%) and except common salt, supplementary feeding was not practiced. Agro-industrial by products is not available in the study district. The total DM yield of species biomass from natural pasture was 1.179ton ha^{-1} of grasses, 0.361ton ha^{-1} of legumes and 0.193 ton $ha^{-1}$of other herbaceous in mid altitude and 1.133ton ha^{-1} of grasses, 0.123 ton ha^{-1} of legumes and 0.171ton ha^{-1} of other herbaceous in low altitude. The overall dry matter production was 1.58ton ha^{-1}; of these 1.156 ton ha^{-1} of grasses, 0.242 ton ha^{-1} and 0.182 ton ha^{-1} of other herbaceous in study area. Therefore the biomass compositions of species as well as dry matter yield per hectare were decreasing from time to time due over grazing in the study area. The average annual dry matter production of natural pasture was 5.08 tons in mid and 3.53 tons in low altitude with over all 4.30 tons per household in the study area. A feed resource from crop residues increasing from time to time, management was varies across agro ecologies mainly in terms of collection, storage and way of utilization.

The chemical composition and nutritive values of major feed resources in the study area was significant different ($p<0.01$) between the agro ecologies. The crude protein content of natural pastures were varies from 7.7% (*Pennisetum sphocelatum)* to 19.1 % (*Medicago burweed)*. The neutral detergent fiber (NDF) content of natural pastures varies from 31.3% (*Vigna vexillata* L. A. Rich) to 73.3% (*Pennisetum sphocelatum)* and the acid detergent fiber (ADF) also varies from 23.40% to 62.0% in similar species. The higher contents of NDF and ADF were characterized by low quality and low digestible feed.

The crude protein content of crop residues varies from 3.94 (sorghum) to 9.19% (nug chuff). The neutral detergent fiber (NDF) content of crop residues varies from 57.53% of nug chuff to 73.02% of haricot bean and the acid detergent fiber (ADF) also varies from 49.80% of nug chuff to 62.3% of haricot bean. Therefore, at the dry season most feed resources were low in nutritional qualities in the study area. The crude protein (CP) contents of fodder trees and shrubs was varies from 6.27% of *Schefflera abyssinica* to 23.85% of *Sepium ellipticum*.

In the study district, free grazing/browsing, tethering, split feeding and cut and carrying were the types of feeding system practiced. The high percentages of respondents practiced free grazing/browsing system indicated the grazing area could be degraded through time unless correction measures are taken.

The overall annual feed supply was 11.87±0.56 tons of DM production, 118.61kg of DCP and 74812.5 MJ of ME per household in study district. Thus, the feed supplies can meet the livestock only 66.13% of DM, 25.81% of DCP and 87.28% of ME in the year. According to the sampled households, in the rest of the months, animals suffer from feed shortage which resulted in weight loses mortality and milk reduction.

The major constraints of livestock production in relation to feed resources were production and reproduction constraints, efficiently utilization of available feed resources and shortage feed due to shortage of grazing land, land degradation and low biomass yield, low quality and variable of feed across the season and weak adoption of improved forage production in the study district.

Therefore, from the current study it was concluded that the availability of feed DM, ME and DCP did not satisfy the maintenance requirements of livestock in the study area. Almost all the available feed resources are also in poor in chemical and nutritional composition especially in dry season. The feed deficit observed in the study area could be one of the contributing factors affecting livestock productivity.

5.2. Recommendations

- The availability of feed DM, ME and DCP did not satisfy the maintenance requirements of livestock units reared in the study area. Alternative means of dry season feed production and supply with use of irrigation should be in place with the involvement of all stakeholders and development actors.
- Due to shortage of grazing land, livestock overgraze the limited land thus land degradation and low biomass yield, low quality and variable of feed across the season. Improve the ways feeding system thus, cut and carry system and tethering of livestock should be encourage for better livestock production and productivities. There should also be land use policy regulation in the area which can secure area for livestock feed production to make the livestock sector contributes to poverty eradication and encourage smallholder farmer to be food secured.
- Utilization efficiency had great problems to the available feed resources in the study area. Therefore, enhancing the efficient utilization of feed resources has to be taken into account with the combined knowledge post harvest managements.
- The chemical composition and nutritive values of natural pasture and crop residues was generally poor in the study district. Thus strategic supplementation of protein and energy rich feeds must be taught to farmers in the area such as *Sapium ellipticum, Ficus ovata, Vernonai amygadalina, Rhoicissus tridentata, Myrsine africana L.* and others.
- Fibrous feeds, like crop residues, with low digestibility constitute the major proportion of feeds under smallholder farmers in study area. Therefore, to improve the digestibility applying alkali or urea, improving harvesting time and storage should be improved.
- To overcome low productivity further studies should be carried out on biotechnological option like balancing of nutrients for the growth of rumen micro flora thereby facilitating efficient fermentative digestion and providing small quantities of by-pass nutrients to inhibit bacterial action so that animal will benefit from by-pass nutrients, enhancing digestibility of fibrous feeds by increasing bacterial populations are an alternative measure and decreasing the population of protozoa is also help to increase bacteria.
- Totally manipulation micro-organisms will help enhancing the rate and extent of digestion of low quality feeds.

6. REFERENCES

Abate A.L. and M. Meyer, 1997. Prediction of the useful energy in tropical feeds from proximate composition and in vivo derived energetic contents 1. Metabolizable the energy. Small Ruminant Res., 25(1): 51-59.

Abdinasir I., 2000. Smallholder dairy production and dairy technology adoption in the mixed farming system in Arsi highland, Ethiopia. PhD Thesis presented to Humboldt University, Berlin, Germany.

Abebe, M., S.J.Oosting, S.Fernandez-Rivera, A.J.Van derijpp, 2008. Multipurpose fodder trees in the Ethiopian highlands: Farmers' preference and relationship of indigenous knowledge of feed value with laboratory indicators. *Article in Agricultural Systems* 96, pp 184–194.

Abeysekara A W A Saman, 2003. The Nutritional Value of Oat Forages for Dairy Cows. MSc Thesis University of Saskatchewan, Saskatoon, Canada, S7N 5A8.

Adane Kitaba, 2003. Effects of stage of harvesting and fertilizer application on dry matter yield and quality of natural grass land in the high lands of north Showa. MSc Thesis. The School of Graduate Studies of Alemaya University, Alemaya, Ethiopia. 96p.

Adane Kitaba and BerhanTamir, 2007. Effect of Harvesting Stage and Nutrient Levels on Nutritive Values of Natural Pasture in Central Highlands of Ethiopia. *Agricultura Tropica ET Subtropica.* Vol. 40 (1), pp.8.

Admasu Terefe, 2006. Pastoralists' perceptions on range-livestock management practices and rangeland assessment in Hamer and Benna-Tsemay districts of South Omo Zone. MSc Thesis Presented to the School of Graduate Studies of Alemaya University, Ethiopia. 159p.

ADO, 2015. Lalo kile Agricultural District Office.

Adugna T. and Said A. N., 1994. Assessment of feed resources in Wolayta Sodo, Ethiopian. *Journal of Agricultural Science*, vol 14, pp. 69-87.

Adugna T., 2007. Feed resources for producing export quality meat and livestock in Ethiopia (Examples from selected Woredas in Oromia and SNNP regional states).

Adugna T., 2008. Feed resources and feeding management. Ethiopia Sanitary & Phytosanitary Standards and Livestock & Meat Marketing Program (SPS-LMM). Texas Agricultural Experiment Station (TAES)/Texas A & M University. September 2008, Addis Ababa.

Adugna T., 2009. Livestock feed supply situation in Ethiopia. Proceeding of the 16^{th} Annual Conference of the Ethiopian Society of Animal Production, October 8-10, 2008, Addis Ababa, pp. 21-38.

Adugna, T., Alamu Y., and Dawit A., 2012. Livestock feed resources in Ethiopia: Challenges, Opportunities and the need for transformation. Ethiopia Animal Feed Industry Association, Addis Ababa, Ethiopia.

Ahamed Hassen Mohammed, 2006. Assessment and utilization practices of feed resources in Basona Worana Woreda of North Showa, An M.Sc. Thesis Presented to the School of Graduate Studies of Haramaya University, Haramaya, Ethiopia.

Ahmed M., S.Ehui and Yemsrach Assefa, 2003. Dairy development in Ethiopia. Socioeconomics and Policy Research Working paper 58. ILRI (International Livestock Research Institute), Nairobi, Kenya, 47p.

Ahmed Hassen, Abule Ebro, Mohammed Kurtu and A C Treydte, 2010. Livestock feed resources utilization and management as influenced by altitude in the Central Highlands of Ethiopia. *Livestock Research for Rural Development.* Volume 22, Article #229.

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

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

Alemayehu Mengistu, 2002. Forage production in Ethiopia: A case study with implication for livestock production. *Ethiopian Society of Animal Production.* pp. 1–125. Addis Ababa, Ethiopia.pp.106.

Alemayehu Mengistu, 2003. Country pasture/Forage resources profiles: Ethiopia. Food and Agriculture Organization of the United Nations (FAO).

Alemayehu Mengistu and Sisay Amare, 2003. Integrated Livestock Development Project (ILDP). Livestock Feed Resources Survey. North Gondar, Ethiopia. pp.75.

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

Alemayehu Mengistu, 2005. Feed resource base of Ethiopia: limitation and opportunities for integrated development. pp 250-259. In Participatory Innovation and Research: Lesson for Livestock Development. Proceeding of the 12th Annual Conference of Ethiopian Society of Animal Production (ESAP), Volume II Technical papers. 12-14 August, Addis Ababa, Ethiopia.

Alemayehu Mengistu, 2006. Forage resource profile of Ethiopia. FAO forage resource profile. FAO, Rome, Italy. http://www.fao.org/ag/agp/AGPC/doc/counprof/

Alemu Yami, Zinash Sileshi and Seyoum Bediye, 1991. The Potential of Crop Residues and Agro-Industrial By-Products as Animal feed. In: proceedings of ESAP, 3rd National Improvement Conference. 24-26 May 1989. IAR, Addis Ababa, Ethiopia. pp. 57-63.

Ali S., Goonewardene L.A. and Basarab JA, 1994. Estimating water consumption and factors affecting intake in grazing cattle. *Canadian Journal of Animal science*. vol.74, 551-554p.

Amaha Kassahun, 2006. Characterization of rangeland resources and dynamics of the pastoral Production system in the Somali region of Eastern Ethiopia. A PhD Thesis Presented to the University of the Free State, Bloemfontein, South Africa. 232p.

Amare Sewnet Minale, 2013. Retrospective Analysis of Land Cover and Use Dynamics in Gilgel Abbay Watershed by Using GIS and Remote Sensing Techniques, Northwestern Ethiopia. *International Journal of Geosciences*, 4, 1003-1008.

AOAC, 1995. Association of Official Analytical Chemists*: Official Methods of Analysis of AOAC International* (16thed.). Virginia, USA.

Aschalew, A., Maleda B., Yalew D. and Shewangzaw A., 2014. Non-conventional Feed Resources and Their Utilization Practice in North Gondar, North West Ethiopia. IDOSI Publications, Academic Journal of Nutrition 3 (3): pp.26-29.

Asfaw, N., Shahidur R., Birhanu G., 2011. Livestock Production and Marketing. Development Strategy and Governance Division, International Food Policy Research Institute Ethiopia Strategy Support Program II, Ethiopia. ESSP II Working Paper 26.

Ashagre Abate, 2008. Effect of Nitrogen Fertilizer and harvesting stage on yield and quality of natural pasture in Fogera district, north western Ethiopia. A MSc. thesis submitted to the School of Graduate studies Haramaya University.94p.

Assefu Gizachew, 2012. Comparative Feedlot Performance of Washera and Horro sheep fed different roughage to concentrate ratio. A MSc. thesis submitted to the school of graduate Haramaya University.129p.

Babayemi, O.J., Bamikole, M.A., 2006. Supplementary value of Tephrosia bracteolate, Leucaena leucocephala, and Gliricidia sepium hay for West African Dwarf goats kept on Range. *Journal Central European Agriculture*, 7(2): 323-328 studies Haramaya University.129p.

Bakrie, J., Hogan, J.E. Liang, AM.M. Tareque and R.C. Upadhyay, 1996. Ruminant Nutrition and Production in the Tropics and Subtropics. Australian Centre for International Agricultural Research Canberra. ACIAR Monograph, No. 36, vi + 151p.

Baumer M., 1992. Tree as Browse to support Animal production. In: Speedy A. and P.L. pugliese (eds). Legume trees and other Fodder trees as protein sources for livestock. *FAO Animal production and Health paper*. FAO, Rome Italy. 120:1-10.

Bayush, T., Adugna T., and B.Trygve, 2008. Livestock production and feed resource constraints in Akaki and Lume districts, central Ethiopia. Outlook on Agriculture 37(1):15-21 Publisher Full Text University of Agriculture, Haramaya. 105pp.

Bedasa Eba, 2012. Study of Smallholder Farms Livestock Feed Sourcing and Feeding Strategies and their Implication on Livestock Water Productivity in Mixed Crop-Livestock Ssystems in the Highlands of the Blue Nile Basin, Ethiopia. MSc Thesis Submitted to the School of Graduate Studies. Haramaya University.139p.

Belay, D., Azage, T. and B.P., Hegde, 2012. Smallholder Livestock Production System in Dandi District, Oromia Regional State, Central Ethiopia. *Global Veterinarian*, 8 (5): 472-479.

Belete Sh., Abubeker H., Tadese A., Nura A. and Abule E., 2012. Identification and Nutritive Value of Potential Fodder Trees and Shrubs in the Mid Rift Valley of Ethiopia. *The Journal of Animal & Plant Sciences*, 22(4), pp. 1126-1132.

Benin, S., Ehui, S. and Pender, J., 2003. Policies for livestock development in the Ethiopian highlands. *Environment Development and Sustainability*, 5: 491-510.

Benin, S., Ehui, S. and Pender J., 2004. Policies affecting changes in ownership of livestock and use of feed resources in the highlands of northern Ethiopia. *Journal of African Economies*, 13: 166-194.

Beyene, T., Tegene N., and Ayana A., 2010. Effects of farming system on Floristic composition, yield and nutrition content of forage at the natural pasture of Assosa Zone (Western Ethiopia). Tropical and Subtropical Agroecosystems12 (3):583–592.

Beyene, T., Tegene N. and Ayana A., 2011. Effect of farming systems on livestock feed resources and feeding systems in Benishangul-Gumuz region, western Ethiopia. *International Research Journal of Agricultural Science and Soil Science.* Vol. 1(1) pp. 020-028.

Bilatu, A., Binyam K., Solomon Z., Eskinder A. and Ferede A., 2013. Forage yield and nutritive value of natural pastures at varying levels of maturity in North West Lowlands of Ethiopia. *World J. Agric. Sci.* 1(3):pp.106-112.

Birhanu, G., Pender, J., and Girmay T., 2004. Collective action for grazing land management in crop–livestock mixed systems in the highlands of northern Ethiopia. *Agricultural Systems 82*(3): 273–290.

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

Bisrat, G., 2014. Characterization of available feed resources in South Gondar zone, Ethiopia. *Journal of Agriculture and Biodiversity Research*..Volume 3(8), pp.126-136.

Blümmel, M., M. Samad, O. P. Singh and Tilahun Amede, 2009. Opportunities and limitations of food-feed crops for livestock feeding and implications for livestock water productivity. *The Rangeland Journal*. 31: 207–213.

Boufennara S., S. Lopez H. Bousseboua R. Bodas and L. Bouazza, 2012. Chemical composition and digestibility of some browse plant species collected from Algerian arid rangelands. Spanish Journal of Agricultural Research, 10(1): 88-98

Cisse M.I., 1980. The Browse Production of some trees of Sahel: Relationships between maximum foliage biomass and various physical parameters. In: Le Houerou, H. N. (eds). Browse in Africa: The current state of knowledge. International livestock center for Africa (ILCA), Addis Ababa, Ethiopia: pp.261-297.

Cochran W.G., 1977. Sampling techniques third edition, John Wiley and Sons. New York.

CSA (Central Statistic Agency), 2011. Ethiopia Demographic and health Survey.55p.

CSA (Central Statistic Agency), 2011. Welfare Monitoring Survey. Analytical Report.280p

CSA (Central Statistical Agency), 2013. Agricultural Sample Survey 2013, Volume II Report on Livestock and Livestock Characteristics (Private and Peasant Holdings) Statistical Bulletin 570. Addis Ababa.

Daniel Keftassa, 1988. Role of crop residues as livestock feed in Ethiopia highlands. In: B.H Dzowela (eds) African Forage Plant Genetic Resources, Evaluation of Forage Germplasm and extensive Livestock production Systems. Proceedings of the Third PANESA workshop held at Arusha, Tanzania, 27-30 April 1987.pp.430-439.

Dawit, A., Ajebu N. and Sandip B., 2013. Assessment of feed resource availability and livestock production constraints in selected Kebeles of Adami Tullu Jiddo Kombolcha District, Ethiopia. *African Journal of Agricultural research.* vol. 8 (29), pp.4067-4073.

Deribe, G.,Abubeker H.,Tsedeke K.,Tekleyohannes B.,Zekarias B.and Addisu J., 2013. Chemical Composition and Digestibility of Major Feed Resources in Mixed Farming System of Southern Ethiopia. IDOSI Publications, *World Applied Sciences Journal* 26 (2):PP. 267-275.

Descheemaeker, K., Amare H., Tilahun A., D. Bossio and T. Tarawali, 2010b. Assessment of water productivity and entry points for improvement in mixed crop-livestock systems of the Ethiopian Highlands. Advances in Animal Biosciences, 1, pp 491-492

Devendra C., 1990. The use of Shrubs and Tree Fodders by Ruminants .In Devendra,(eds).Shrubs and Tree Fodders for Farm Animal's. Proceeding of a Work Shop, 24-29 July 1989, Denpasar Indonesia International development research center, Ottawa Canada.

Devereux, S., 2000. Food insecurity in Ethiopia. *A discussion paper for DFID* (pp. 1–16).

De Leeuw, P.N. and J.C. Tothill, 1990. The concept of rangeland carrying capacity in Sub-Saharan Africa-myth or reality. Pastoral Development Network Paper 29b. Overseas Development Institute, London.

Diriba G., Mekonen H., Ashenafi M. and Adugna T., 2013. Herbage Yield and Quality of Selected Accessions of Centrosema Species Grown under Sub humid Climatic Conditions of Western Oromia, Ethiopia. *Global Veterinaria,* 11 (6): pp.735-741.

ELDMPS (Ethiopia Livestock Development Master Plan Study), 2007. Livestock Development Master Plan Study, Volume 1-Dairy. Phase 1 Report- Data collection and Analysis. Government of Ethiopia Ministry of Agriculture and Rural Development. (www.igaddata.org/index.php).

Endale Yadessa, 2015. Assessment of Feed Resources and Determination of Mineral Status of Livestock Feed in Meta Robi District, West Shewa Zone, Oromia Regional State, Ethiopia. MSc Thesis Submitted to the School of Graduate Studies of Ambo University, Ambo University.122p.

Ensminger RE, Oldfield JE, Heineman WW., 1990. Feed and Nutrition. (2^{nd} edition). The Ensminger publishing company, P. 1151.

Esubalew Abate, 2002. Study of the Feed situation of local cattle and Feeding strategies for crossbred dairy cows in the Ethiopian highlands. PhD Dissertation to BOKU University of Natural Resources and Applied life Sciences. Vienna, Austria, 97p.

FAO (Food and Agriculture Organization of the United Nations), 1986. Ethiopian highland reclamation study. Final report. Vol. 1, FAO, Rome.

FAO (Food and Agricultural Organizations of the United Nations), 1987. Master Land Use Plan, Ethiopian Rangeland/Livestock Consultancy Report Prepared for the Government of the Peoples Democratic Republic of Ethiopia. Food and Agricultural Organization of the United Nations. Technical Report.AG/ETH/82/020/FAO, Rome. 94p.

FAO (Food and Agricultural Organizations of United Nations), 2001. Grassland Resources Assessment for Pastoral Systems. FAO Plant Production and Protection Paper No.162. 150p.

FAO (Food and Agriculture Organization of the United Nations), 2002. Animal Production Based on Crop Residues; China's Experiences. FAO Animal Production and Health Paper No. 149. 39p

Fekede F., Agajie T. and Argaw T., 2011. Producing and Using Alternative Feeds to Crop Residues. *Ethiopian Institute of Agricultural Research, Addis Ababa, Ethiopia*.

Fekede, F., Sh. Prasad, Getnet A.,Seyoum B., Getu K., Aemiro K. and Gezahegne K., 2014. Dynamics in nutritional characteristics of natural pasture hay as affected by harvesting stage, storage method and storage duration in cooler tropical highlands. *African Journal of Agricultural Research.* vol.9 (43), pp.3233-3244.

Firew, T. and Getnet A., 2010. Feed resource assessment in Amhara regional state. Ethiopian Sanitary and Phytosanitary Standards and Livestock Meat Marketing Program (SPS-LMM), Texas A&M University System.

Getachew Eshete, 2002. An assessment of Feed Resources, their Management and Impact on Livestock productivity in the Ginchi Watershed Area. MSc Thesis Presented to Graduate Studies of Haramaya University of Agriculture, Haramaya.171p.

Getachew A., 2005. Evaluation of Forage Yield and Effects of Forms of Feeding of Acacia saligna L. on Intake and Live weight gain of Farta Sheep Fed on Grass Hay. An MSc Thesis Presented to the School of Graduate Studies of Haramaya University of Agriculture, Ethiopia.

Gezu, T., Haftu K. and Sefa S., 2014. Feed resources and constraints for cattle fattening in Lemo and Soro Woredas, Hadya zone, Southern Ethiopia. *Global Journal of Animal Science, Livestock Production and Animal Breeding.* Vol. 2 (4), pp. 119-125

Girma Defar, 2010. Effects of urea treatment and concentrate mix supplementation on feed intake, digestibility, weight gain and carcass characteristics of Horro sheep fed maize husk. MSc Thesis presented to School of Graduate Studies of Haramaya University, Ethiopia.

Girmay, G., Singh, B. R., and Dick, Ø., 2010. Land-use changes and their impacts on soil degradation and surface runoff of two catchments of Northern Ethiopia. *Acta Agriculturae Scandinavica, Section B – Soil and Plant Science 60*(3): 211–226.

Habtamu Teka, I.Casper Madakadze, Ayana Angassa and Abubeker Hassen, 2012. Effect of Seasonal Variation on the Nutritional Quality of Key Herbaceous Species in Semi-arid Areas of Borana, Ethiopia. *Indian J. Anim. Nutr*. 29 (4): pp.324-332.

Herlocker, D., 1999. Rangeland Ecology and Resource Development in East Africa. GTZ.Nairobi, Kenya.393p.

Jim Linn and Carla Kuehn, 2007. The Effects of Forage Quality on Performance and Cost of Feeding Lactating Dairy Cows. University of Minnesota, Department of Animal Science.

Johanston P. W., G. M. McKeon and K.Day, 1996. Objective 'safe' grazing capacities for South-West Queensland, Australia: Development of a model for individual properties. *Journal of Rangelands.*18:244–258.

Jutzi S, Haque I, Abate T., 1987. The Production of Animal Feed in the Ethiopian Highlands: Potentials and Limitations: *In:* Proceedings of the 1st National Livestock Improvement Conference, Addis Ababa, Ethiopia. pp. 141-142.

Kawas J. R, N. A. Jorgensen, A. R Hardie, M. Collins, and G. P. Barrington, 1989. Assessment of alfalfa quality with change in maturity and concentrate level. Univ. of Wisconsin-Madison College of Ag. and Life Sciences, Rep. No. R3460.

Kazemi, M., A.M. Tahmasbi, A.A. Naserian, R. Valizadeh and M.M. Moheghi, 2012. Potential nutritive value of some forage species used as ruminants feed in Iran. *African Journal of Biotechnology.*

Kearl, L.C., 1982. Nutrient Requirements of Ruminants in Developing Countries. Utah Agricultural Experimental Station, Utah State University, International Food Stuff Institute, Logan, USA.

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

King J M., 1983. Livestock water needs in pastoral Africa in relation to climate and forage. ILCA Research Report 7. ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia95p.

Kossila, V., 1984. Location and potential feed use. In: Sundstøl, F. and Owen, E. (Eds). pp. 4-24.

LDMPS, 2006. Livestock development master plan study. Phase I. Addis Ababa, Ethiopia.

LDHAD, 2015. Livestock Development and Health care Agency of Lalo kile district.

Lemma G., Abubeker H., and Diriba, G., 1996. Adaptation and yield performance of herbaceous and multipurpose tree legumes in sub-humid climate of Western Ethiopia. Proceedings of the 4^{th} National Conference of Ethiopian Society of Animal Production (ESAP). 187-195p.

Lemma, G., Adane H., Fikadu J. and G. N. Smit, 2002. Mineral element status of soils, native pastures and cattle blood serum in the mid-altitude of western Ethiopia. *African Journal of Range and Forage Science*, 19(3): 147-155.

Leng R A., 2009a. Decline in available world resources - implications for livestock production systems. *Proceedings, International Symposium on Sustainable Improvement of Animal Production and Health*. International Atomic Energy Commission, Vienna Austria.

Luseba D and Van der Merwe D., 2006. Ethno veterinary medicine practices among Tsonga speaking people of South Africa. *Onderstepoort Journal of Veterinary Research 73: 115- 122*.

Mannetje, 1978. Measuring quality of grassland vegetation. In: Measurement of grassland vegetation and animal production. Bulletin of common wealth Agricultural Bureau of Pasture and Field Crops. No. 52. Hurley. UK. pp. 63-91.

Mannetje, L't., 2000. Measuring biomass of grassland vegetation. Pages 151-177 in Field and Laboratory Methods for Grassland and Animal Production Research. Mannetje, L.'t., and R. M. Jones, ed. C.A.B.I. Publishing. Univ. Press, Cambridge, U.K.

Mapiye C., Chimonyo M., Dzama K., Strydom P. E, Muchenje V. and Marufu M C., 2009. Nutritional status, growth performance and carcass characteristics of Nguni steers supplemented with Acacia Karroo leaf meal. Livestock Science, Volume 126, pp. 206–214.

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

McDonald P, Edward R A, Greenhalgh J F D and Morgan G A., 2002. Animal Nutrition (6th ed.), Pearson Educational Limited, Edinburgh, Great Britain, pp. 544.

McDonald P., Edwards R.A, Greenhalgh J.F.D, Morgan C.A, Sinclair L.A, and Wilkinson R.G, 2010. Animal Nutrition. 7th ed. Prentice Hall, London. pp. 300.

Meeske R., Rothauge A., Van der Merwe, G. D. and Greyling J. F., 2006. The effect of concentrate supplementation on the productivity of grazing Jersey cows on a pasture based system. South African J. Anim. Sci. 36 (2), 105-110.

Melese Gashu, 2008. Effect of supplementation with noug seedcake, wheat bran and their mixtures on feed intake, digestibility and live weight change of Washera sheep fed urea treated finger millet straw. MSc. Thesis Presented to Graduate Studies of Haramaya University, Ethiopia.

Melese, G., Berhan, T. and Mengistu, U., 2014. Effect of Supplementation with Non-Conventional Feeds on Feed Intake and Body Weight Change of Washera Sheep Fed Urea Treated Finger Millet Straw. *Greener Journal of Agricultural Sciences*, 4(2): pp.067-074.

Mertens D.R., 2002. Fiber: measuring, modeling and feeding. Proc. 64th Cornell Nutrition Conference for Feed Manufacturers. pp. 1-18.

Mohamed-Saleem, M. A. and Abate Tadela, 1995. Feed Improvement to Support Intensification of Ruminant Production Systems in the Ethiopian Highlands. *In:* Proceedings of the 3rd National Conference of the Ethiopian Society of Animal Production, Addis Ababa, Ethiopia, pp.27-29 April 1995.

Mohamed Saleem, M. A. and Abyie Astatke, 1998. Livestock management as a strategy for improving land-use and conservation of natural resources in the mixed crop–livestock production systems of East African Highlands. Animal production systems and the environment. An international conference on Odor waters quality, nutrient management and socio-economic issues. 2: pp.223.

Mtimuni J.P., 1976. The nutritive evaluation of cereal silages using growing steers and chemical methods. MSc Thesis Dept. of Animal and Poultry Science, University of Saskatchewan, SK, Canada.

Mulugeta Ayalew, 2005. Characterization of Dairy Production Systems of Yerer watershed in Ada Liben Woreda, Oromia Region, Ethiopia. MSc Thesis Presented to the School of Graduate Studies of Haramaya University, Haramaya University. 140 p.

Mulugeta Sisay and Kindu Mekonen, 2013. Tree and Shrub Species Integration in the Crop-Livestock Farming System. *African Crop Science Journal*, Vol. 21(3), pp. 647 – 656.

Niderkorn V. and R. Baumonta, 2009. Associative effects between forages on feed intake and digestion in ruminants. *Animal*, 3: pp.951-960.

NRC (National Research Council), 1996. Nutrient requirements of beef cattle. (7th Ed) National Academy of Sciences, Washington DC, USA

NRC (National Research Council), 2001. Nutrient requirements of dairy cattle. Seventh Revised Edition. National Academy Press. Washington, D.C., USA.

Nurfeta, A., 2010. Feed intake, digestibility, nitrogen utilization and body weight change of sheep consuming wheat straw supplemented with local agricultural and agro-industrial byproducts. Tropical Animal Health and Production, Volume 42, pp. 815-824.

Pet Mark M.V., 1983. Primary production, Nutrient cycling and OM turnover of tree plantation after agricultural intercropping practices in north east Thailand. PhD Dissertation. University of Philadelphia, Los Banos, Philadelphia. 228p.

Reddy D V. and Elanchezhian N., 2008. Evaluation of tropical tree leaves as ruminant feedstuff based on cell contents, cell wall fractions and polyphenolic compounds. *Livestock Research for Rural Development. Volume 20, Article #77.*

Rehrahe Mesfin, 2001. Biological and economical evaluation of feeding urea treated teff and barley straw based diets to crossbred milk cows in the highlands of Ethiopia. M.Sc. Thesis. Swedish University of Agricultural science, Uppsala, Sweden.

Rehrahe M., Johannes G. and Agajie T., 2003. Milk yield and economic evaluation of two concentrate feeds to crossbred Boran x Friesian (BF) and Boran Jersey (BJ) dairy cows at Holeta Research Centre. In: Challenges and Opportunities of Livestock Marketing in Ethiopia. Proc.10th Annual Conference of the Ethiopian Society of Animal Production (ESAP) held in Addis Ababa, Ethiopia, pp. 347-354.

Rehrahe M. and Ledin I., 2004. Comparison of feeding urea-treated teff and barley straw based diets with hay based diet to crossbred dairy cows on feed intake, milk yield, milk composition and economic benefits. Livestock Research for Rural Development, Volume 16 (12), Article # *104* http://www.lrrd.org/lrrd16/12/mesf16104.htm

Sarwar M., Khan M.A. and Iqbal Z., 2002. Feed resources for livestock in Pakistan. Int.J. Agric. Biol. 4 (1), 186–192.

SAS, 2008. Statistical Analysis System Software, version 9.2 SAS/STAT program SAS Institute Inc.Carry, NC, USA.

Senbeto, F., Tegene N., Getahun L., 2010. Feed Resources and their Management Systems In Ethiopian Highlands: The Case Of Umbulo Wacho Watershed In Southern Ethiopia. *Tropical and Subtropical Agro-ecosystems*, 12(1): 47-56

Seyoum, B., Getnet A., Abate T. and Dereje F., 2001. Present Status and future direction in feed resources and nutrition research targeted for wheat based crop livestock production system in Ethiopia: In P.C. Wall (eds). Wheat and Weed: Food and Feed. Proceedings of Two-stakeholder workshop. CIMMYT, Mexico City. Improving the productivity of crop livestock production in wheat based farming systems in Ethiopia, Addis Ababa. 10-11 October 2000. pp 207-226.

Seyoum B., and Fekede F., 2008. The status of animal feeds and nutrition in the West Shewa Zone of Oromia, Ethiopia. Holetta Agricultural Research Center, EIAR.

Seyoum Bediye and Zinash Sileshi, 1989. The Composition of Ethiopian Feed stuffs, Research Report no. 6. Institute of Agricultural Research; Addis Ababa, Ethiopia. 33p.

Seyoum Bedeye and Zinash Sileshi. 1995. Chemical composition in vitro digestibility and energy value of Ethiopian feedstuffs. In: proceedings of the 3rd annual conference of the Ethiopian Society of Animal Production (ESAP) held in Addis Ababa, Ethiopia, 27-29 April 1995.pp. 307-311.

Seyoum, B., Zinash S.and Dereje F., 1999. Chemical composition and nutritive values of Ethiopian feeds. Ethiopian Institute of Agricultural Research. Research Report 73, Addis Ababa, Ethiopia.

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

Shitahun Mulu, 2009. Feed Resources Availability, Cattle Fattening Practices and Marketing System in Bure Woreda, Amhara Region, and Ethiopia.Ms.c.thesis. A MSc. thesis submitted to the School of Graduate Studies, Mekelle University. 120p.

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

Sisay Amare, 2006. Livestock Production Systems and Available Feed Resources in Different Agro-ecologies of North Gondar Zone, Ethiopia. MSc Thesis presented to School of Graduate Studies of Haramaya University, Dire Dawa, Ethiopia. 95p.

SNV (Netherlands Development Organization), 2008. Study on Dairy Investment Opportunities in Ethiopia. Addis Ababa.

Solomon Bogale, 2004. Assessment of Livestock Production Systems Feed Resource base in Sinana Dinsho district of bale highlands, Southeast Oromia, MSc. Thesis, Haramaya University, Dire Dawa, Ethiopia

Solomon, B., Solomon M. and Alemu Y., 2004. Influence of rainfall pattern on grass/legume composition and nutritive value of natural pasture in Bale Highlands of Ethiopia, pp: 1-11.

Solomon Tefera, H.A.Snyman and G.N.Smit, 2007. Rangeland dynamics in southern Ethiopia: (1) Botanical composition of grasses and soil characteristics in relation to land-use and distance from water in semi-arid Borana rangelands. *Journal of Environmental Management*.85 pp.429–442

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

Solomon, B., Solomon M., Alemu Y., 2008a. Potential use of crop residues as livestock feed resources under smallholder farmers' conditions in Bale highlands of Ethiopia. Tropical and Subtropical Agro ecosystems, vol.8. pp.107-114

Solomon, B., Solomon M. and Alemu Y., 2009. The Interdependence of Crop - Livestock Production Sectors: The Case of Sinana Dinsho District in Bale Highlands of Ethiopia. *Agricultura Tropica ET Subtropica*. Vol. 42 (2).

Solomon, M., Aregawi T., and Lisanework N., 2010. Chemical composition, in vitro dry matter digestibility and *in sacco* degradability of selected browse species used as animal feeds under semi-arid conditions in Northern Ethiopia, Agro forest Syst., 80: 173-184.

SPSS (Statistical procedure for social science), 2012. (Version 20), Statistical procedures for social sciences (SPSS) INC, Chicago, USA

Steinbach J., 1997. Alternatives to crop residues as resources in mixed farming systems. CAB International, Wallingford, UK.

Streeter S., 2006. Feeding livestock in temporary holding facilities in the Northern Territory, Australia. http://www.nt.gov.au/d/Content/File/p/Anim_Man/831.

Tadesse B., Zelalem Y., Yohannes G. and Alemu G., 2003. Nutrient utilization efficiency of lactating crossbred dairy cows supplemented different levels of concentrate diets. In: Proceedings of the 10th annual conference of the Ethiopian Society of Animal Production (ESAP) held in Addis Ababa, Ethiopia, pp. 341-346.

Takele, G., Lisanework N., Getachew A., 2014. Evaluation of Potential Yield and Chemical Composition of Selected Indigenous Multi-Purpose Fodder Trees in Three Districts of Wolayta Zone, Southern Ethiopia. *World Applied Sciences Journal* 31 (3): 399-405

Tarawali S.A., Tarawali G., Larbi A. and Hanson J., 1995. *Methods for the Evaluation of Legumes,* Grasses and Fodder Trees for Use as Livestock Feed. ILRI Manual 1. ILRI (International Livestock Research Institute), Nairobi, Kenya. pp. 51.

Teferi Aregawi, 2006. Identification and Nutritional Characterization of Major Browse species in Abergelle Woreda of Tigray. MSc Thesis Presented to the School of Graduate Studies of Haramaya University.75p.

Tesfaye Alemu, 2006. Studies on the Utilization of Crop Residues And The Potential of Urea Treated Maize Stover For Cattle Performances In East Shoa Zone, Ethiopia. PhD. Thesis presented to Kasetsart University.

Tesfaye A. and Chairatanayuth P., 2007. Management and feeding systems of crop residues: the experience of East Shoa Zone, Ethiopia. *Livestock Research for Rural Development.* Volume 19, Article No. 31.Retrieved September 21, 2014, from http://www.lrrd.org/lrrd19/3/tesf19031.htm

Tesfaye Desalew, 2008. Assessment of feed resources and rangeland Condition in Metema district of north Gondar zone, Ethiopia. MSc Thesis submitted to the department of Animal sciences, school of graduate studies Haramaya University. 161p

Tessema Zewdu, 2003. Identification of indigenous pasture and the effect of time of harvesting and nitrogen fertilizer in the north western Ethiopian high lands. *Trop.sci*.45: 73-77.

Thairu, D.M. and S. Tessema, 1985. Research on animal feed resources: Medium-potential areas of Kenya. Animal feed resources for small-scale livestock producers - Proceedings of the second PANESA workshop, held in Nairobi, Kenya, 11-15 November 1985.

Thomson, D., 2007. Profitable Grazing-Based Dairy Systems. Range and Pasture Technical Note No. 1.

Tilahun Amede, Solomon Mengistu and Ralph Roothaert, 2005. Identification of Livestock Feed Production in Ethiopian Highlands: Potential and Experiences of the African Highlands Initiative. Presented at the 19th EVA Annual conference, 8 June 2005, ECA, Addis Ababa

Tothill J. C., R. M. Jone and N.G. Hargreaves, 1978. BOTANAZ: A Field and Computing package for assessment of plant biomass and botanical composition, Ecology and Management of World Savannas. 399p.

Ulfina, G., Jiregna D., and Alganesh T., 2013. Dairy production potential and challenges in Western Oromia Milk Value Chain, Oromia, Ethiopia. *Journal of Agriculture and Sustainability.* Vol.2 (1), pp.1–21

Van Soest, P.J. Mertens D.R. and Deinum B., 1978. Pre-harvest factors influencing quality of conserved forage. J. Anim. Sci. 47: 712.

Van Soest, P.J., 1982. Nutritional Ecology of Ruminant. Cornel University Prentice, Ithaca and London

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

Van Soest P. J. and J.B. Robertson, and B. A. Lewis, 1991. Methods for dietary fiber. Neutral detergent fiber and non-starch polysaccharides in relation to animal nutrition. *Journal of Dairy Science.* Vol.74, 3583-3597p

Van Soest P.J. 1994. Nutritional ecology of ruminants. O & B Books. Corvallis, OR.

WIIAD (Winrock International Institute for Agricultural Development), 1992. Assessment of Animal Agriculture in Sub-Saharan Africa. Winrock: Morrilton, Arkansas.

Willms WD,Kenzie OR, McAllister TA,Colwell D,Veira D,Wilmshurst JF,Entz and Olson ME, 2002. Effects of water quality on cattle performance. *Journal of Range Management* .vol.55, 452-460.

Yayneshet T., 2010. Feed Resources Available in Tigray Region, North Ethiopia, For Production of Export Quality Meat and Livestock Addis Ababa Ethiopia, pp: 9-16.

Yeshitila Admasu, 2008. Assessment of Livestock Feed Resources Utilization in Alaba *Woreda*, Southern Ethiopia. MSc. Thesis Submitted to the Department of Animal Sciences, School of Graduate Studies Haramaya University.127p.

Yihalem Denekew, 2004. Assessment of Botanical Composition and Harvesting Stage of Selected Natural Pasture for Optimum Utilization as Hay at Andassa Livestock Research Center, North-Western Ethiopia. MSc Thesis Haramaya University of Agriculture, Haramaya.69 p.

Yisehak Kochero and G.P.J.Janssens, 2014. The Impacts of Imbalances of Feed Supply and Requirement on Productivity of Free-Ranging Tropical Livestock Units: Links of Multiple Factors. *African Journal of Basic & Applied Sciences* 6 (6):pp 187-197, 2014

Yoseph Mekasha, 1999. Impact of feed Resources on productive and reproductive performance of Dairy cow in the Urban and peri-urban Dairy production system in the Addis Ababa milk shed and evaluation of Non-conventional Feed Resources using sheep, M.Sc. Thesis Haramaya University of Agriculture, Haramaya. 177p.

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

Zewdie Wondatir, 2010. Livestock production systems in relation with feed availability in the Highlands and Central Rift valley of Ethiopia. MSc Thesis submitted to the School of Animal and Range Sciences, School of Graduate studies Haramaya University.160p.

Zewdie, W., Yoseph M.and B. Wouters, 2011. Assessment of productive and reproductive performance of dairy cattle nexus with feed availability in selected peri-urban areas of Ethiopia. *Journal of Cell and Animal Biology* Vol. 5 (15), pp. 308-315.

Zinash, S. and Seyoum B., 1998. The Composition of Ethiopian Feed stuffs, Research Report no. 6.Institute of Agricultural Research (IAR), Addis Ababa, Ethiopia, pp: 28-33.

Zinash Sileshi, Seyoum Bediye, Lulseged Gebrehiwot and Tadesse Tekletsadik, 1995. Effect of Harvesting Stage on Yield and Quality of Natural Pasture in the Central Highland of Ethiopia. In: Proceeding of the 3rd Annual Conference of the Ethiopian Society of Animal Production (ESAP) Held in Addis Ababa, Ethiopia,27-29 April 1995.

7. APPENDIXES

7.1. Appendix A

Appendix Table 1: List of shrubs and trees, grasses, legumes and forbs species identified as livestock feeds in Lalo kile district

Scientific name	Vernacular Name (Afan Oromo)	% of res- pondents(n)	Edible parts	Livestock species	Type of fodders
Rhoicissus tridentata	laaluu	87.8%(58)	Leaf, twigs	Cattle(calf),sheep, goats	shrubs
Acanthus polystachius Delile	sokorru	81.8%(104)	leaf	Goats &sheep	shrubs
Teclea nobilis	gurshane	62.3%(38)	leaf	Cattle, sheep & goats	shrubs
Combertum paniculatum	baggee	65.3%(83)	Leaf	Cattle, goats, sheep	shrubs
Myrsine africana L.	Qacama dima	68.8%(42)	Lea f	Cattle sheep and goats	shrubs
Zehneria scara	Hidda reffa	63.9(39)	root	cattle	shrubs
Impatiens tinctoria	Ansosilla	54%(33)	root	Cattle, sheep & goats	shrubs
NA	shaaro	62%(41)	Leaf, twigs	Cattle(calf)	shrubs
Maytenus gracilipes	konbolcha	49.2%(30)	leaf	Goats & sheep	shrubs
Verbascus sinaiticum	Gurra harre	62.3%(38)	leaf	Cattle & donkey	shrubs

NA=not available

Continued

Scientific name	Vernacular Name (Afan Oromo)	% of res-pondents(n)	Edible parts	Livestock species	Type of fodders
Carissa spinarum	Hagamsa	45%(57)	leaf	Goats & sheep	shrubs
Coronopus didymus	suruma	52.4%(32)	Leaf	Cattle ,sheep & goats	shrubs
Mirabilis jalapa	Ababa dima	27.55%(35)	root	Cattle	shrubs
Buddleja polystachya	Hanfaaree	27.5%(35	Leaf, twigs	Cattle, goats	shrubs
Impatiens rothii Hook.	Ancote gafarsa	35.4%(26)	root	Cattle	shrubs
Ficus palmata Forsk	Lugoo	35.4%(26)	leaf	Cattle, horse &donkey	Shrub
NA	Cakko	35.9%(24)	leaf	Sheep & goats	shrubs
Ricinus comiunis	Qobbo	42.4%(28)	leaf	Goats ,sheep & cattle	shrubs
Vernonia colorata	Soyama	42%(53)	shoots	Cattle & goats	shrubs
Sesbania sesban	Sasbania	54.3%%(69)	Leaf, twigs	Cattle,sheep,goat, equine	shrubs
Leucaena leucocephala	Lucerne	51.2%(65)	Leaf, twigs	Cattle, sheep and goat	shrubs
Ensete ventricosum	Warqee	42.6%(26)	Leaf, steam	Cattle	shrubs
Musa paradisiaca	Banana leaf	45.5%(57)	Leaf ,steam	Cattle, sheep, goats,donkey	shrubs

Continued

Scientific name	Vernacular name (Afan Oromo)	% of respondents	Edible parts	Livestock species	Type of fodders
Carissa spinarum L.	Agamsa	35.4%(26)	Leaf	goats	shrubs
Grewia ferruginea Hochst.	Dhoqonuu	27.5%(35)	Leaf	Cattle, goats	shrubs
Indigofera spicata Forssk.	Reencii	19.7%(25)	Leaf	Cattle and donkey	shrubs
Phytolacca dodecandra L' Heri	Andoodee	14.1%(18)	Leaf	Cattle and donkey	shrubs
Ocimium lamifolium Hoch	Hancabbii	11.8%(15)	Leaf	Cattle	shrubs
Crotalaria spinosa	Komborree	29.5%(18)	Leaf ,pods	Donkey, horse	shrubs
Premna schimperi	Urgessa	18.8%(15)	leaf	Cattle, goats	trees
Ficus thonningii Blume	Dambi	69.1%(87)	leaf	Cattle, sheep &goats	tree
Sapium ellipticum	Bosoqa	93.3%(118)	leaf	Cattle, sheep & goats	tree
Ficus sur Fossk	harbu	82.3%(104)	Leaf, pods	Cattle & goats	tree
Bersama abyssinica	lolchisa	68.5%(87)	Steam, wood ash	cattle	tree
Schefflera abyssinica	Afarfattu	66.4%(84)	Steam, wood ash	cattle	tree
Combretum collinum	Dhandhamsa	66%(40)	leaf	Cattle, sheep, goats	tree
Ficus ovata	Dambi jabbi	90%(59)	Leaf, twigs	Cattle, sheep & goats	tree
Ficus thonningii Blume	Dambii	69.1%(87)	leaf	Cattle,sheep,goat	tree
NA	madalle	78.3%(48)	leaf	Cattle, sheep &goats	tree

NA=not available

Continued

Scientific name	Vernacular name (Afan Oromo)	% of respondents	Edible parts	Livestock species	Type of fodders
Albizia gumifera	Ambabeessa	73.4%(93)	steam	Cattle, sheep &goats	tree
Acacia abyssinica Hochst	Lafto	45.5%(58)	leaf	Cattle, sheep and goats	tree
Ficus vasta Forssk	Qiltu	65.3%(83)	pod, leaf	Cattle , sheep &goats	tree
Cordial africana	Waddessa	45.2%(57)	leaf	Cattle, goats	tree
Grewia ferruginea	xaxessa	38.3%(23)	leaf	Cattle & goats	tree
NA	Wandabiyo	45.6%(28)	leaf	Cattle, sheep & goats	tree
NA	Dhayire	51.4%(31)	leaf	Cattle, sheep & goats	tree
Teclea nobilis	hadhessa	58.3%(35)	leaf	Cattle, sheep & goats	tree
NA	Gatama	33.2%(20)	leaf	Cattle, sheep & goats	tree
Vernonai amygadalina	Ebicha	82.5%(54)	leaf	Cattle sheep & goats	tree
Rubus apetalus Poir	Goraa	78 %(51)	leaf	Cattle, sheep & goats	tree
Catha edulis (Vahl.) Forssk.	Caatii	19.7%(25)	Leaf	sheep & goats	tree
Brucea antidysentrica J.F. Mil	Qumunyoo	39.3%(24)	leaf	Cattle and donkey	tree

Continued

Scientific name	Vernacular name (Afan Oromo)	% of respondents	Edible parts	Livestock species	Type of fodders
Syzygium guineanse	baddessa	14.0%(18)	leaf	cattle	tree
Ficus lutea vahl.	qilimxoo	17.3%(22)	leaf	cattle	tree
Olea europaea	Ejersa	19.7(25)	leaf	Cattle ,goats	tree
Stereospermum chunthianum	Botoroo	24.5%(15)	Pods, leaf	Cattle, goats	tree
Pennisetum clandustinum	Coqorsa	96%(63)	leaf, twigs	Cattle,sheep,goat, equine	grass
Digitaria abyssinica	Warati	98%(124)	leaf	Cattle,sheep,goat, equine	grass
Pennisetum sphocelatum	Migra	75%(95)	leaf	Cattle,sheep,goat, equine	grass
Berchemia discolor	jajjaba	43.6(26)	leaf	Cattle, equine	grass
Cymbopogon citrates (DC. Stapf	Marga citaa	36.0%(22)	leaf	Cattle, sheep, goats and equine	grass
Snowdine polystarch	gargaara	68%(86)	leaf	Cattle,sheep,goat, equine	grass
Plantago lanceolata L.	qorxobbi	46.4%(59)	leaf	Cattle,sheep,goat, equine	grass
Dignathia hirtella Stapf	Qamboo	31.1(19)	leaf	Cattle and equine	grass

Continued

Scientific name	Vernacular name (Afan Oromo)	% of respondents	Edible parts	Livestock species	Type of fodders
Red grass	Marga dima	22% (28)	leaf	Cattle,sheep,goat, equine	grass
Cyperus sp.	Incinni (qunni)	15%(9)	leaf	Donkey, horse mule	grass
Panicum hochstetteri Steud.	Marga gogorri	23%(14)	Leaf	Cattle, equine	grass
Pennisetum purpureum	Elephant grass	72.4%(92)	Leaf	Cattle,sheep,goat, equine	grass
Medicago burweed	Siddisa	57.4%(73)	Leaf	Cattle,sheep,goat, equine	legumes
Trifoliu burchellionum	Hasangira	31.8%(21)	Leaf	Cattle,sheep,goat	legumes
Grewia bicolor Juss	Haroressa	24.6%(15)	Leaf	Cattle,sheep,goat, equine	legumes
Vigna vexillata L. A. Rich.	Gurra hantuta	69.3%(88)	Leaf , twigs	Cattle,sheep,goat, equine	legumes
Chloris gayana	Rhodes grasses	16.5%(21)	Leaf	Cattle, sheep, goat, equine	grass
Avena sativa	oats	7.0%(9)	Leaf	Cattle, sheep, goat, equine	grass
Lablab purpureus	lablab	4.0%(5)	Leaf	Cattle, sheep, goat, equine	legumes
Aristida kenyensis Henr	Biilaa	22% (28)	Leaf	Cattle, sheep, goat, equine	grass
Snowdenia polystachya	Mujjaa	35.4%(45)	Leaf	Cattle ,Sheep and goats	grass

Continued

Scientific name	Vernacular name (Afan Oromo)	% of respondents	Edible parts	Livestock species	Type of fodders
Saccharum officinarum L.	Shankora	4.7%(6)	leaf	Cattle ,sheep, goat,donkey	grass
Cucumis ficifolius A. Rich	Facaa`a	52%(66)	Root	Cattle	legumes
Ageratum conyzoides	Tuufoo	35.4%(45)	Leaf	Sheep and goats	legumes
Bidens rueppellii	Keello	36.2%((46)	Leaf	Sheep & goats	legumes
Lippia adoënsis Hochst	Kusaye	29.1%(37)	Leaf ,twigs	Cattle	other herbs
Aspilia mossambicensis	Hadaa	27.6%(35)	Leaf	Cattle, sheep and goat	legumes
Cucurbitaceae, Cucurbita L.	Buqqee	35%(45)	Steam	Cattle, donkey, goat	legumes
Colocasia esculenta L. Schott	Goodarree	11.8%(15)	leaf	Cattle and donkey	legume
Impatiens tinctoria A. Rich.	Qicuu	19.6%(25)	root	Cattle	legume
Agave sisalana	Qaacaa	32.7%(20)	leaf	cattle	legumes
Rhynchosia ferruginea A. Rich	Kalaalaa	20.4%(26)	leaf	Cattle,sheep,goat	other herbs
Cynoglossum lanceolatum	Maxxannee	23.4%(30)	leaf	Sheep and goats	other herbs
NA	karabii	20.4%(26)	Leaf, twigs	Cattle,sheep,goat	other herbs
Calpurnia subdecandra	ceekaa	19.6%(25)	Leaf, twigs	Cattle,sheep,goat	other herbs

Appendix Table 2: Conversion factors used for estimation of the amount of crop residues or fibrous by-products produced from different crops and land dry matter yield

Crop Residues	Conversion factors (ton DM/ha/year)
Barley straw	1.5
Wheat straw	1.5
Teff straw	1.5
Oats straw	1.7
Rice straw	1.3
Maize straw	2.0
Finger millet stover	2.0
Sorghum stover	2.5
Pulse crops stover	1.2
Cassava tops	1.0
Sugar cane tops	0.3
Sweet potato vines	0.3
Others Roots and tubers	0.3
Noug chuff	4.0
Linseed straw	4.0
Vegetables waste	0.25
Enset and banana	8.0
Natural pasture	2.0
Private grazing land	3.0
Communal grazing	2.0
Fallow land	1.8
Aftermath	0.5
Improved forages	8.0
Wood, bush and shrubs	1.2
Irrigation land	0.3

(Kossila, 1984; FAO, 1987; Adugna, 2007)

Appendix Table 3: Conversion factors of livestock number to Tropical Livestock Unit (TLU) and Daily Dry matter Requirements (DDMR), ME and DCP for livestock species

Type of animals’	Conversion factors(TLU)	Dry mater(Kg)	Metabolizable energy(MJ/kg)	Crude protein (g/kg)
Oxen	1.1	4.8	33	361.3
Bulls	1.1	4.8	33	361.3
Cows	0.8	4.4	29.7	227.8
Heifers	0.5	3.3	21.7	232
Calves	0.2	1.9	13	144
Sheep	0.1	0.65	4.3	53
Goats	0.1	0.64	5	49
Donkey	0.5	2.5	14.9	192.5
Horses	0.8	5.3	27.6	400.4
Mule	0.7	5.3	27.6	27.6
Camels	1	9	36	210
poultry	0.01	-	-	-

Source: ILRI, (2002); Kearl (1982); McCarthy (1986) and Wilson (1984)

Appendix Table 4: ANOVA for dry matter (DM) composition of natural pastures in mid altitude

Source	DF	Sum of squares	Mean Square	F Value	Pr > F	R^2	CV	mean	MSE
Model	10	35.53350370	3.55335037	5.08	0.0021	0.760447	0.925935	90.33259	0.836422
Error	16	11.19361481	0.69960093						
Corrected Total	26	46.72711852							

Appendix Table 5: ANOVA for Crude Protein (CP) composition of natural pastures in mid altitude

Source	df	Sum of squares	Mean Square	F Value	Pr > F	R^2	CV	mean	MSE
Model	10	267.2655556	26.7265556	164.57	<.0001	0.990371	3.026516	13.31556	0.402997
Error	16	2.5985111	0.1624069						
Corrected Total	26	269.8640667							

Appendix Table 6: ANOVA for Neutral detergent fiber (NDF) composition of natural pastures in mid altitude

Source	df	Sum of squares	Mean Square	F Value	Pr > F	R^2	CV	mean	MSE
Model	10	3334.397037	333.439704	298.36	<.0001	0.99466	2.349637	44.99259	1.057163
Error	16	17.881481	1.117593						
Corrected Total	26	3352.278519							

Appendix Table 7: ANOVA for Acid detergent fiber (ADF) composition of natural pastures in mid altitude

Source	df	Sum of squares	Mean Square	F Value	Pr > F	R^2	CV	mean	MSE
Model	10	2721.570370	272.157037	343.62	<.0001	0.995365	2.502504	35.56296	0.889965
Error	16	12.672593	0.792037						
Corrected Total	26	2734.242963							

Appendix Table 8: ANOVA for Dry matter (DM) composition of natural pastures in low altitude

Source	df	Sum of squares	Mean Square	F Value	Pr > F	R^2	CV	mean	MSE
Model	10	21.22148148	2.12214815	13.32	<.0001	0.892739	0.441940	90.32815	0.399197
Error	16	2.54972593	0.15935787						
Corrected Total	26	23.77120741							

Appendix Table 9: ANOVA for Crude protein (CP) composition of natural pastures in low altitude

Source	df	Sum of squares	Mean Square	F Value	Pr > F	R^2	CV	mean	MSE
Model	10	236.3412370	23.6341237	599.58	<.0001	0.997339	1.558071	12.74259	0.198539
Error	16	0.6306815	0.0394176						
Corrected Total	26	236.9719185							

Appendix Table 10: ANOVA for Neutral detergent Fiber (NDF) composition of natural pastures in low altitude

Source	df	Sum of squares	Mean Square	F Value	Pr > F	R^2	CV	mean	MSE
Model	10	2912.468148	291.246815	201.89	<.0001	0.992137	2.314384	51.89630	1.201080
Error	16	23.081481	1.442593						
Corrected Total	26	2935.549630							

Appendix Table 11: ANOVA for Acid Detergent Fiber (ADF) composition of natural pastures in low altitude

Source	df	Sum of squares	Mean Square	F Value	Pr > F	R^2	CV	mean	MSE
Model	10	3529.925926	352.992593	488.88	<.0001	0.996738	2.124713	39.99259	0.849728
Error	16	11.552593	0.722037						
Corrected Total	26	3541.478519							

Appendix Table 12: ANOVA for dry matter (DM) composition of crop residue in mid altitude

Source	df	Sum of squares	Mean Square	F Value	Pr > F	R^2	CV	mean	MSE
Model	7	35.02722222	5.00388889	9.11	0.0012	0.864384	0.804568	92.13889	0.741320
Error	10	5.49555556	0.54955556						
Corrected Total	17	40.52277778							

Appendix Table 13: ANOVA for crude protein (CP) composition of crop residues in mid altitude

Source	df	Sum of squares	Mean Square	F Value	Pr > F	R^2	CV	mean	MSE
Model	7	61.27605556	8.75372222	862.81	<.0001	0.998347	1.881931	5.352222	0.100725
Error	10	0.10145556	0.01014556						
Corrected Total	17	61.37751111							

Appendix Table 14: ANOVA for neutral detergent fiber (NDF) composition of crop residues in mid altitude

Source	df	Sum of squares	Mean Square	F Value	Pr > F	R^2	CV	mean	MSE
Model	7	296.1022222	42.3003175	18.51	<.0001	0.928362	2.298018	65.77778	1.511585
Error	10	22.8488889	2.2848889						
Corrected Total	17	318.9511111							

Appendix Table 15: ANOVA for Acid detergent fiber (ADF) composition of crop residue in mid altitude

Source	df	Sum of squares	Mean Square	F Value	Pr > F	R^2	CV	mean	MSE
Model	7	190.6022222	27.2288889	32.54	<.0001	0.957939	1.648978	55.47778	0.914816
Error	10	8.3688889	0.8368889						
Corrected Total	17	198.9711111							

Appendix Table 16: ANOVA for dry matter (DM) composition of crop residue in low altitude

Source	df	Sum of squares	Mean Square	F Value	Pr > F	R^2	CV	mean	MSE
Model	5	5.14418333	1.02883667	2.34	0.1654	0.660793	0.722381	91.83667	0.663411
Error	6	2.64068333	0.44011389						
Corrected Total	11	7.78486667							

Appendix Table 17: ANOVA for crude protein (CP) composition of crop residues in low altitude

Source	df	Sum of squares	Mean Square	F Value	Pr > F	R^2	CV	mean	MSE
Model	5	15.09449167	3.01889833	33.05	0.0003	0.964959	6.196839	4.877500	0.302251
Error	6	0.54813333	0.09135556						
Corrected Total	11	15.64262500							

Appendix Table 18: ANOVA for neutral detergent fiber (NDF) composition of crop residues in low altitude

Source	df	Sum of squares	Mean Square	F Value	Pr > F	R^2	CV	mean	MSE
Model	5	60.63461667	12.12692333	24.21	0.0007	0.952779	1.019931	69.38833	0.707713
Error	6	3.00515000	0.50085833						
Corrected Total	11	63.63976667							

Appendix Table 19: ANOVA for Acid detergent fiber (ADF) composition of crop residue in low altitude

Source	df	Sum of squares	Mean Square	F Value	Pr > F	R^2	CV	mean	MSE
Model	5	107.3028833	21.4605767	43.29	0.0001	0.973027	1.222561	57.59167	0.704093
Error	6	2.9744833	0.4957472						
Corrected Total	11	110.2773667							

Appendix Table 20: ANOVA for dry matter (DM) composition of shrubs and fodder trees in mid altitude

Source	df	Sum of squares	Mean Square	F Value	Pr > F	R^2	CV	mean	MSE
Model	11	28.68200000	2.60745455	13.70	<.0001	0.893298	0.483565	90.22000	0.436272
Error	18	3.42600000	0.19033333						
Corrected Total	29	32.10800000							

Appendix Table 21: ANOVA for crude protein (CP) composition of shrubs and fodder trees in mid altitude

Source	df	Sum of squares	Mean Square	F Value	Pr > F	R^2	CV	mean	MSE
Model	11	1328.192503	120.744773	4594.49	<.0001	0.999644	1.000384	16.205	0.162112
Error	18	0.473047	0.026280						
Corrected Total	29	1328.665550							

Appendix Table 22: ANOVA for neutral detergent fiber (NDF) composition of shrubs and fodder trees in mid altitude

Source	df	Sum of squares	Mean Square	F Value	Pr > F	R^2	CV	mean	MSE
Model	11	840.7633067	76.4330279	52.60	<.0001	0.969831	2.524877	47.74133	1.205410
Error	18	26.1542400	1.4530133						
Corrected Total	29	866.9175467							

Appendix Table 23: ANOVA for Acid detergent fiber (ADF) composition of shrubs and fodder trees in mid altitude

Source	df	Sum of squares	Mean Square	F Value	Pr > F	R^2	CV	mean	MSE
Model	11	1321.886213	120.171474	148.31	<.0001	0.989087	2.325199	38.71333	0.900162
Error	18	14.585253	0.810292						
Corrected Total	29	1336.471467							

Appendix Table 24: ANOVA for dry matter (DM) composition of shrubs and fodder trees in low altitude

Source	df	Sum of squares	Mean Square	F Value	Pr > F	R^2	CV	mean	MSE
Model	9	57.53541667	6.39282407	141.88	<.0001	0.989155	0.234328	90.58750	0.212272
Error	14	0.63083333	0.04505952						
Corrected Total	23	58.16625000							

Appendix Table 25: ANOVA for crude protein (CP) composition of shrubs and fodder trees in low altitude

Source	df	Sum of squares	Mean Square	F Value	Pr > F	R^2	CV	mean	MSE
Model	9	361.0496542	40.1166282	2317.52	<.0001	0.999329	1.218457	10.79792	0.131568
Error	14	0.2423417	0.0173101						
Corrected Total	23	361.2919958							

Appendix Table 26: ANOVA for neutral detergent fiber (NDF) composition of shrubs and fodder trees in low altitude

Source	df	Sum of squares	Mean Square	F Value	Pr > F	R^2	CV	mean	MSE
Model	9	806.2250000	89.5805556	85.12	<.0001	0.982053	1.889528	54.29167	1.025856
Error	14	14.7333333	1.0523810						
Corrected Total	23	820.9583333							

Appendix Table 27: ANOVA for Acid detergent fiber (ADF) composition of shrubs and fodder trees in low altitude

Source	df	Sum of squares	Mean Square	F Value	Pr > F	R^2	CV	mean	MSE
Model	9	887.3033333	98.5892593	113.04	<.0001	0.986426	2.038310	45.81667	0.933886
Error	14	12.2100000	0.8721429						
Corrected Total	23	899.5133333							

7.2. Appendix B

Questionnaire Format

Data collection

1. Name of enumerator`s ______________________ Date of data collection________
2. Data collection: Starting time _____________ending time___________________
3. Questionnaire number ________

I. Survey site (Location)

Region: ________Zone _______Woreda _______Kebele_________ Altitude (masl) __________

II. Household and farming system characteristics

A. Household characteristics

a. Name of householder: ____________________ Age: _____Sex: _____

b. Educational status: a) illiterate ii) Read and write c) Primary (1-8) d) Secondary and above

c. Family size: male______ female_____ sum_____

d. Marital status a) single b) married c) widow d) widower

e. Religion: a) Catholic b) orthodox c) Muslim d) Seventh Day Adventist e) protestant

B. Land holding and management of grazing land

1) Total area of Land owned by the householder_________________ ha

2) Land holding and use pattern

No	Land use	Private (ha)	Communal(ha)	Total
1	Crop land			
2	Fallow land			
3	Grazing land			
4	Road side grazing			
5	Forest /coffee			
6	woodland			
	Total land holding			

C. **Farming system characteristics**

1. What is the type of the farming system in the area? a) crop-livestock mixed farming
   b) Crop production c) agro pastoral d) pastoral e) others
2. What are the major crops cultivated in your farm? Rank in order of importance (1, 2, 3...)

a) Barley____ b) wheat____ c) bean____ d) pea_____ e) mustard/sesame ___f) Teff_____ g)Maize____ h) sorghum ____i) finger millet____ j) noug ____k) haricot ____l) others____.

3. What is your main source of income? List in the order of importance? a)coffee_____ b)noug____,c)sesame___d)honey___d)livestock____e)chat_____f)others(specify)___

4. Livestock production

No	Livestock species	Herd size	Trend in the last ten years (increase or decrease)	Reason for the change in the trend
1	Cattle			
2	Sheep			
3	Goats			
4	Donkey			
5	Horse			
6	Mule			
7	poultry			
8	beekeeping			

5. Livestock herd size and composition

No	Cattle type	number			
		Indigenous	Crossbreed	Exotic	Total
1	**cows**				
	- Pregnant				
	- Lactating				
2	Heifers				
3	Bulls				
4	Male calves				
5	Female calves				
6	steers				
	sheep				
1	Ewe				
2	Ram				
3	lamb				
	goats				
1	Doe				
2	Bucks				
3	Kids				
	Equine				
1	donkey				
2	Horse				
3	mule				
	poultry				

6. What are your objectives of livestock keeping? List in order of importance a) Milk___ b) meat___ c) draught power____ d) income____ e) social security____ f) hide and skin _____ h) manure______ i) transport______ j) specify__________________________

7. The major constraints of livestock production in your area (rank in order 1, 2, 3…)?

No	Constraints	Cattle	Small Ruminants	Equines
1	Shortage of Feed			
2	Shortage of grazing land			
3	Health problem/disease			
4	Low genetic breeds			
5	Predator			
6	Water Scarcity			
7	Scarcity of Labor			
8	Market link			
9	Other –specify			

III. Production and reproduction performances livestock

a. what type of dairy breeds do you have? i. local ii. Cross iii. Full exotic iv. cross breed

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

i) Local breed: wet season _________lit/day/cow, Dry season ________lit/day/cow

ii) Crossbred: wet season ________liter/day/cow, Dry season _________ liter/day/cow

iii) What is the price of liquid milk per liter? _____________________

c. Lactation length: i) Crossbred cows______days/month ii) local cows_____days/months

e. Age at first calving: a) local ________years/months b) crossbred ______years/months

f. Calving interval: a) local______ months/year b) crossbred cows_____ months/year

g. Day open: a) local cows ______b) crossbred cows___________

h. Number of service per conception local ________________b)exotic______________

i. The maximum productive age: a) local bred cows? ____years b) Exotic breed____ year

j. Draught age ______________________year

k. Draught life span __________________year

l. Age at first lambing____ month, lambing interval_________ Age of slaughter________.

m. Age at first kidding______ month, kidding interval_________ Age of slaughter______.

n. Age at working horse______ Donkey ____ mule __________month

IV. Livestock health problems and housing

1. What are the major livestock diseases and parasites in the area? List in the order of importance

   Cattle: a) ________b) __________c) __________d)___________e) _________ f) ______

   Small ruminant: a) ________b) __________c) __________d)___________e) __________

   Equine: a) ________b) __________c) __________d)___________e) _________ f)______

   Poultry: a) ________b) __________c) __________d)___________e) _________ f) _____

2. How do you house your livestock? a) Separately in corral b) Mixed in corral c) Mixed in barn d) separately in barn e) in the farmer's house mixed with people f) Other (specify) ____

V. Feed resources and feeding system of livestock

1. What are the feed resources available to livestock in your area? List them in the order of their importance (1,2,3…).

   a) Grazing land_____ b) Crop residues ______C) Improved forage and pasture______

   d) Household left over, if so tell the type of the left over and name it_________________

   e) road side_____ f) Tree legumes/shrubs grown as hedge or any_____ g) crop aftermath__

   h) others specify____

2. What are the major feed resources available for livestock in the area? (Rank in the order of importance 1,2,3…)

   a) Natural grazing/pasture**:**

   i) What are the Grass Species available to livestock in your area? a)_________ b)_______

   c)__________ d___________ e)____________ f)_________g)__________ h)_________

   i)_________ j)______ k)________ l)_______ m_________ n)______ o)_____________

   ii) What are the Legumes species available to livestock in your area? a)___________

   b)_________ c)_________ d___________ e)____________ f)_________ g)__________

   h)_________ i)_________ j)______ k)________ l)_______ m_________ n)___________

   b) What are the Crop residues available to livestock in your area? a)maize _____ b)sorghum _______ c)finger millet________ d) teff ______e) barley______ f)wheat_____ g) pulse crop residues (faba bean ,chick pea and haricot)______ h) oil crop residues (noug, linseed)_______ i)oats_______ j)others(specify)______________

c) Fodder trees/Browse

i) What are the Trees/woody species available to livestock in your area? a)____________ b)_________ c) _________ d___________ e)____________ f)_________g)__________ h)_________ i)_________ j)______ k)________ l)_______ m_________ n)_________ o)_________ p)________

ii) What are the Shrubs species available to livestock in your area?

a)__________________ b)_________ c)_________ d) ___________e)____________ f)_________g)____________ h)____________ i)_________ j)______ k)________ l)_______ m_________ n)__________

iii) What are the cultivated forages available to livestock in your area? a)Sesbania __________ b) Lucerne _____ c)elephant grass______ d)oats _____ e)lablab ____ f) Desmodium _____ g)Rhodes grass_______ h)guinea grass_________ i)cow pea________ j)others(specify)___________, ___________ ,_______ ,_________ ,______

d) What are the Agro industrial byproducts available to livestock in your area? a) Brewery __ b) wheat bran_________ c) edible oil extracting by-products (nug, sesame and linseed) ____ d) milling by products(maize, sorghum and finger millet)__________ e) *atela*_____ f)local extraction(*Ebicha*) _________ g)others(specify) ___________

e) What are the Non conventional feed resources in your area? a) Banana leaf_____ b) sugar cane leaf________ c) tea waste and coffee waste______ d) fruit and vegetable waste (mango, papaya, potato, avocado)_____ e) maize cobs_____ f) Others____________________________

3. Which type of feeding system are you using? a) Only grazing/browsing, b) Grazing and stall-feeding c) Only stall-feeding d) cut and carry feeding system e) tethering others____

4. If you are using stall-feeding, what are the feed items you supply to livestock?

a) Concentrate ____ b) hay__________c) milling by-products ________d) silage________

d) If others specify____________________________

5. What is the grazing system? a) Continues b) paddock c) free grazing d) others___________

6) Is there communal grazing land? a) Yes b) No

7) If yes what the size of your communal grazing land in the last five years? a) Decreasing

b) Increasing c) remains constant

8) If decreasing why?

a) Expansion of farm land b) Soil degradation c) Increasing in livestock number.

d) Policy of Land use e) other (specify)____

9) What is the type of communal grazing land in the area? a. Open grassland b. Tree covered grassland c. Bush land grassland d. Grazing pasture and fodder trees/shrubs

10) Do you preserve pasture as hay? A. Yes B. No,

11) If you make hay, how do you decide appropriate cutting time? a. Pattern of rain fall b. Plant growth c. Depending on need of animal d. Other specify)____________________

12) Do you have private grazing land? a) Yes b) No

13) If yes which animals is/are given priority to graze?

No	Types of livestock	Rank		
		Private	Communal	remark
1	Lactating cow			
2	Dry cow			
3	Pregnant cow			
4	Non pregnant			
5	heifers			
6	Traction oxen			
7	Sheep			
8	Goats			
9	Equine			

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

No	Crop type	Proportion of grain yield (kun)	Quantity of DM yield in kg
1	Maize		
2	Sorghum		
3	Millet		
4	Wheat		
5	Barley		
6	Teff		
7	Linseed		
8	Bean		
9	Field pea		
10	Oats		
11	Haricot bean		
12	Oilseed (nug)		
13	others		

15) Do you allow your animals to feed on crop residue? 1) Yes 2) No

16) If yes, in which months of the year can you feed your animal's crop residue? __________

17) In what form do you feed crop residue to your livestock?

a) Whole b) chopped c) treated d) mixed with other feeds e) other (specify)_____________

18) How do you store crop residues? a) Stacked at open field b) Stacked under shed c) Baled outside d) Baled under shed e) others (specify) ________________________________

19) For how long do you store crop residue before feeding?

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

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

21) If yes, in which and how many months of the year can you feed your animal's crop aftermath? ____

22) Do you use any non-conventional feed resources? (1) Yes (2) No

If yes what is the name and amount given? Name and amount in kg per animal ____

23) Have you offered browse to your livestock? a)Yes b) No

If yes, list down the type of browse species you offer in different seasons accordingly

At dry season____

____

At rainy season____

____

24) Trunk diameter of trees and shrubs

No	Name of trees/woody plant	Diameter size in cm
1		
2		
3		
4		
5		
6		
	Name of shrubs	Diameter size in cm
1		
2		
3		
4		
5		

25) 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.

a)Grasses____

b)Legumes____

c) Fodder tree____

26) If you do not plant improved forage crops, what is your reason?

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

f) Others (specify)______________________________________

27) Have you ever purchased supplement feed for livestock? a) Yes b) No

28) If yes, what types of supplementation feed do you purchased?) a) Industrial by product b) Mineral supplements, c) Concentrates d) Others (specify) ___________________________

29) If No, Why? a) high cost______ b)not available____ c)lack of awareness_____ d)others_

30) When supplementation is highly demanded? a) Dry season b) wet season c) Always

d) Others (specify) ____

31) Do you produce crops by irrigating for livestock? 1. Yes 2. No, if yes how many _____ha and ____ times per annum? Name the crop types _________________________________and yield (kg/ha)_____________________________________respectively.

32) Do you consider high quality and quantity of feed in selecting the crops you grow in relation to livestock feeds? A. Yes B. No

33) What indicators do you use for feed quality? a) Palatability b) Color c) More leafy d) Smell e) Texture f) others (specify) __________________________

34) What are the sources of water for your livestock? River b) Pond c) Rain d) spring water

35) What is the average distance traveled by livestock for watering?

Distances watered at home	Wet Season Dry season	Wet Season Dry season
< 1 km		
1-5 km		
6-10 km		
> 10 km		

36) Specify the type and quantity of feed you offered for each group of livestock for maintenance.

Livestock types	Quantity supplied per day per animal in kg												
	pasture	concentrates				Crop residues							
	hay	Nug cake	Wheat bran	silage	molasses	maize	sorghum	teff	wheat	Finger millet	barley	bean	others
cattle													
sheep													
goats													
equine													
Poultry													

37) What are the traditional medicinal plants used for livestock in your area? ______________

____

38) What are the traditional plants used for milk production in your area? _________________

____

39) What are the traditional plants used for fattening in your area? _______________________

____

40) List the plants toxic/ant-nutritional factors/ to livestock in your area _________________

____

VI. Feed Constraints

1. Major feed source and feeding system constraints in your area (rank 1, 2, 3…12 where 1 is the most important constraint and 12 is the least important constraint)

No	Constraints	Rank	Remark
1	Shortage of rainfall		
2	Livestock population pressure		
3	Shortage of grazing land		
4	Livestock Production constraint		
5	Land degradation and low biomass yields		
6	Low quality and variability of feed across seasons		
7	Water logging on grazing land		
8	Lack of extension services		
9	Lack of high quality forage seeds		
10	Lack of knowhow on improved feeding		
11	Poor access to feed market		
12	Poor storage facilities/techniques		

2. How many hours and kilometer walking to grazing area per/day from night penning?

Livestock group	Dry season		Wet season	
	In kilometers	In hours	In kilometers	In hours
Cattle				
Calf				
Sheep and goat				
Equines				

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

If yes, specify the seasonality of feed available and Indicate year round.

No	Type of feed	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	Communal grazing												
2	Road side grazing												
3	Stubble grazing/after math												
4	River side grazing												
5	Private grazing												
6	Crop residues												
7	Fodder trees												
8	Improved forges												
9	Roots and tubers												
10	Weeds												
11	Maize thinning												
12	Sorghum thinning												
13	Fallow land grazing												
14	Supplements/concentrates												
15	Hay												

4. What are the consequences of the feed shortage? List in order

a. Weight loss_______ b. Milk yield reduction ___c. Increased mortality ____ d. Abortion frequency ___ e. Animals remain unproductive for longer period__ f) Do not come in heat g) others, specify____

5. What are the measures taken to alleviate feed shortage? a) feed conservation b)Purchase of concentrate c)saw /planting the improved forages d)Migration e)Other (specify)____

____.