



SCHOOL OF GRADUATE STUDIES

**ASSESSEMENT OF MAJOR LIVESTOCK FEED RESOURCES,
FEED BALNCE AND NUTRITIONAL VALUE IN SODDO
DISTRICT, EAST GURAGE ZONE, CENTRAL ETHIOPIA**

MSC THESIS

BY

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Wolkite, Ethiopia

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Assessment of Major Livestock Feed Resources, Feed Balance and
Nutritional Value in Soddo District, East Gurage Zone, Central Ethiopia

**A Thesis Submitted to the Department of Animal Sciences, Collage of
Agriculture and Natural Resource**

**In Partial Fulfillment of the Requirements for the Degree of
Master of Science in Animal Production and Technology**

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LIST OF ABBREVIATIONS AND ACRONYMS

ADF	Acid Detergent Fiber
AOAC	Association of Official Agricultural Chemists
CP	Crud Protein
CSA	Central statistics Agency
DA	Development Agent
DCP	Digestible Crude Protein
DM	Dry Matter
CP	Crude Protein
EE	Ether Extract
FAO	Food and Agricultural Organization
GDP	Gross Domestic Product
GL	Grazing land
HH	House holds
IBP	Industrial by- Products
IVDMD	In Vitro Dry Matter Digestibility
MAFF	Ministry of Agriculture, Fisheries and Food
ME	Metabolize Energy
N	Nitrogen
NDF	Neutral Detergent Fiber
NRC	National Research Council
PA	Peasant Association
SNNPRS	Southern Nations Nationalities and Peoples Regional State
SPSS	Statistical Package for Social Sciences
SWADO	Soddo wereda Agriculture development office
TDM	Total dry mater
TLU	Tropical Livestock Unit

TABLE OF CONTENTS

APPROVAL SHEET	ii
DECLARATION	iii
BIOGRAPHICAL SKETCH.....	4
ACKNOWLEDGEMENTS	5
LIST OF ABBREVIATIONS AND ACRONYMS	6
ABSTRACT	11
1. INTRODUCTION.....	12
1.1. Background	12
1.2. Statement of the Problem.....	15
1.3. Significant of the Study	15
1.4. Objectives	16
1.4.1. General Objective	16
1.4.2. Specific Objectives	16
2. LITRATURE REVIEW	17
2.1. Importance of Feed Resources Assessment and Livestock Productivity..	17
2.2. Livestock Feed Sources in Ethiopia.....	18
<i>2.2.1. Natural pasture.....</i>	<i>18</i>
<i>2.2.2. Crop residues.....</i>	<i>19</i>
<i>2.2.3. Agro-industrial by-products as animal feed.....</i>	<i>19</i>
<i>2.2.4. Improved forage</i>	<i>20</i>
<i>2.2.5. Non- conventional feed sources</i>	<i>20</i>
2.4. Feed Balance	21
3. MATERIALS AND METHODS	22
3.1. Description of Study Area.....	22
4. RESULTS	29
4.1. Household Characteristics	29
<i>4.2. Landholding and Land Use System.....</i>	<i>31</i>
5. DISCUSSIONS	43
5.1. Demographic Characteristics of Households	43
5.2. Landholding and Land Use System.....	44
5.3. Livestock feed Management.....	45
5.4. Chemical Composition and Nutritive Value of Feeds	45

5.6. Estimated Annual Feed Balance.....	49
6. CONCLUSION AND RECOMMENDATION	51
6.1. Conclusion `	51
6.2. Recommendation	52
7. REFERENCES	53
APPEDICES	65

LIST OF FIGURES

Figure 1 Map of the study area.....	23
Figure 2 Inter view	67
Figure 3 Interview	68
Figure 4 Teff straw conservation methods in soddo district.....	69
Figure 5 Maize straw conservation methods in soddo district.....	70
Figure 6 feed conservation methods in midland area of soddo district.....	71
Figure 7 Water source in mid land in Soddo District East Gurage zone	72

LIST OF TABLES

Table 1 Household characteristics of the study area in highland and mid agro-ecological	29
Table 2 Average landholding/HH and land use pattern in the study area of soddo district (Mean±SD).....	31
Table 3 Annual field crop yield and crop residues in tons per HHs in the study area of soddo district of Gurage zone (mean ±SD)	33
Table 4: Major livestock feed resource and feeding system in the study area	35
Table 5: Chemical composition and nutritive value of feed in study area of soddo district	39

ABSTRACT

The objective of this study was to assess livestock feed resource, feed balance and nutritional values at different agro ecologies of Soddo district, east Gurage zone, central Ethiopia. The kebeles of the district were stratified in to two agro- ecological zones and representative kebeles were selected from the two agro-ecology. A total of 166 sampled respondents were selected by simple random sampling and data were collected by using semi- structure questionnaire interview and personal observation. The result of the study showed that the livestock production system in the district was a mixed crop-livestock production system. The overall family size per household was 6.72 ± 0.27 in high land agro ecology and 7.45 ± 0.33 in midland agro ecology , the average cattle population per household was 7.17 ± 0.30 heads (6.84 TLU), and the overall land holding was 1.29 ± 0.325 ha per household in this study. . In the highland agro-ecology of the study areas, the major feed resources of cattle were crop residue, natural pasture, and Enset leaf while it was natural pasture and crop residue in midland agro-ecology. Annual feed supply in the district satisfies 68.9% and 79.7% TDM; 44.83% and 39.36% TDCP, and 69.46% and 83.25% TME of the maintenance requirement of livestock in TLU per year in highland and midland agro-ecologies, respectively. Major livestock constraints are shortage of feed, high-cost feed, inadequate extension and training service. Therefore, different intervention strategies are needed to improve the husbandry practices, mainly to improve the feed resource available and. Cattles feed deficit was serious problem and needs strong intervention and attention by the concerned bodies.

Key words: Chemical composition, Constraints, Feed resources, Feed balance

1. INTRODUCTION

1.1. Background

With an estimated 70.29 million cattle, 40 million sheep, 51 million goats, 9.9 million donkeys, 2.1 million horses, 0.35 million mules, 8 million camels, 49 million poultry, and 6.9 million beehives, Ethiopia has the most livestock in Africa (CSA, 2020–21). Local breeds make up 97.4 percent of the overall cattle population, with hybrid and alien types making up the remainder (CSA 2020–2021). About 60–70 percent of Ethiopia's population depends on the sector for their livelihoods, which includes paying farmers a living wage, providing jobs, ensuring food security, offering services, preserving assets, social, cultural, and environmental values, and sustaining livelihoods (FAO, 2018). In Ethiopia, the livestock industry generates 150.7 billion ETB annually, which accounts for 17 percent of the country's GDP and 39 percent of its agricultural GDP. The percentage rises to about 21 percent (Shapiro *et al.*, 2017).

Due to complex factors in the livestock industry, such as inadequate feed and nutrition, widespread diseases, low genetic potential of local breeds, market issues, and ineffective livestock development services with regard to credit, extension, marketing, and infrastructure, the enormous number of livestock has not met the estimated production and services (FAO, 2018). One of the main issues affecting Ethiopia's livestock industry is feed, which is limited in terms of both quantity and quality, as many academics have noted (Ahmed *et al.*, 2004). Ethiopia is reported as having a significant lack of food due to periodic droughts and climate change (DPDAO, 2015).

Green pasture and crop leftovers are the main and readily available feed sources in Ethiopia, contributing 54.54 percent and 31.13 percent of the annual need, respectively (CSA, 2020a). In addition to the two primary resources, hay, agro industrial byproducts, enhanced forage, and other types all provide 7.35, 1.53, and 2.03 percent respectively to the collective (CSA, 2020a).

Hay and agro-industrial byproducts, enhanced forage, and other types in the collective additionally contribute 7.35percent, 1.53percent, 2.03percent, and 4.37percent, respectively, outside of the two primary resources (CSA, 2020/2021). Other sources of feed in Ethiopia include weeds, brewer's grains, a by-product of the native *Tella* (beer), stubble grazing created after harvesting seasons, and to a lesser extent, agro-industrial by-products such wheat bran, oil cake, and molasses (Feyissa *et al.*, 2014; Geleti *et al.*, 2014b).

The main source of food for animals is natural grassland, which is plentiful in the wet season. It is sometimes gathered during the rainy season and saved as hay for the dry season (Duressa *et al.*, 2014; Feyissa *et al.*, 2014; Geleti *et al.*, 2014b; Abate, 2012). The natural grazing is in risk in Ethiopia. The size and productivity of the natural grazing resources are declining due to competition with cropland, overstocking, and climate change respectively (SNV, 2017). According to published research, natural pasture contribution peaked at 54.59percent (CSA, 2017/2018) before falling to 52.2 percent (CSA, 2020a) over a two-year period..

Teff (*Eragrostis teff*) straw, barley, wheat, residues from legumes including fava beans and field peas, as well as Stover from sorghum and maize, are examples of crop residues (Duressa *et al.*, 2014; Tegegne *et al.*, 2013; Duguma *et al.*, 2012; Abate, 2012). On the other hand, crop residues are characterized by poor voluntary intakes, low digestibility, and low nitrogen, energy, mineral, and vitamin contents, even if they have the capacity to replace natural pasture and there is variance among crop types (cereal and legume) (Alemu *et al.*, 1991). Crop residues' content ranges from 2.4 to 7percent, while straw's IVDMD value is between 34 and 52percent. According to the SDANRDO (2019) research, the quickest rate of crop residue replacement by grazing land resources is happening in the study area, Soddo district due to the completion of farmland as a result of population growth, a lack of youth employment possibilities, and an absence of a land use policy in place. Additionally, SDLFDO (2019) said that while efforts had been made to increase forage under farmer's gardens, utilization could meet around 80percent of the livestock's annual feed requirements

In Ethiopia, efforts have been made to enhance ruminant nutrition through the investigation of local feed supplies and the

introduction of improved genotypes (Getnet, 2003), but these efforts have been found to be less successful, primarily because of issues with adaptability. The poor use of the available feed resources is the other major issue that arises in Ethiopian animal agriculture. During the period when extra feed is produced, the resources are subjected to significant sun damage, moisture-related deterioration, and burning on farmland. The other issue is a lack of district base quantification. As a result, rather than merely in times of need, as is the case following every tragedy, feed resources should be taken into account in a wider perspective.

In order for the nation and its regional base to be aware of their demands, resource availability, gaps, consequences, and how the gaps can be addressed inside the nation, region, or beyond the regional base or district base, study and the institutionalization of a feed security system are essential. This will make country-wide feed interventions effective in the short, medium, and long terms and offer remedies for replication at the national level (FAO, 2018). Environmentally sustainable stocking rates are also determined by evaluations of present and future supplies and needs for animal feed (FAO, 2018). Policymakers, government organizations, non-governmental organizations, intergovernmental organizations, and development organizations could greatly benefit from the data provided by livestock feed inventories in developing and putting into practice sustainable livestock development initiatives. A lack of national-scale feed assessments for area-based focuses has made it difficult to accurately describe the effects of feed shortages at the district or mixed agricultural area level, even though it is obvious that livestock-feed shortages have limited output in many nations. The efficiency and profitability of the animal feed sector will also increase thanks to information on the availability of feed ingredients at the regional or farm system level, which will also help researchers develop sustainable feeding strategies (FAO, 2018).

The feed inventory generates information and data on what, how much and where various feed resources exist while feed balance determines the balance between the available, nutritional value and demand. This work will focus on feed inventory and feed balance of Sodo district which is in mixed farming system and has practiced utilization of crop residue as basal feed for 6-9 months a year for livestock.

1.2. Statement of the Problem

It is evident that the majority of research projects on the assessment of feed resources in various regions of the country to date undertaken simply indicated the scarcity of feeds without identifying the major accessible feed resources, not only in Soddo district but also in the country in general. This makes it extremely difficult to provide a potential fix to cow farmers, especially during Ethiopia's severe drought seasons. In order to make recommendations for improving the existing feed resources, introducing new feed alternatives, or suggesting development and policy interventions for each agro ecology, it is crucial to assess the existing feed resources nutritional quality in the study Soddo district Kebeles in relation to the requirements of cattle on an annual basis in the study area.

1.3. Significant of the Study

Planning and implementing sound cattle production techniques that primarily benefit producers requires estimating the present and potential cattle feed resources available in a particular area. It's also crucial to comprehend the degree of seasonal gaps in the availability of various feed items if you want to use effective supplementation tactics. The information would inform them of when to practice cattle rearing based on the seasonal variability of feed resources and show different problems that they have in their area, and should be given information as an input for. As a result, the findings of this work have significance for the farmers and the government, as well as for different NGOs who want to practice cattle rearing based on the available cattle feed resources in the study area.

For the purpose of defining environmentally sustainable stocking rates as well as for national food security policy and planning, assessments of the existing and future supply and needs for livestock feed are required. In order to gather data for the creation and execution of policies that will eventually support the sustainable expansion of the country's livestock industry, feed resources must be evaluated and monitored (FAO, 2018). The feed-inventory data will make it possible to generate feed balances at the national,

regional, or district levels, which will aid in the proper planning of the livestock industry.

1.4. Objectives

1.4.1. General Objective

- To assess the available livestock feed resource, feed balance and its nutritional value in Sodo district, Gurage zone, Central Ethiopia.

1.4.2. Specific Objectives

- To identify and estimate the available feed resource in the study area
- To assess the chemical composition of livestock feeds in the study area

2. LITRATURE REVIEW

2.1. Importance of Feed Resources Assessment and Livestock Productivity

Currently, domestic production primarily satisfies the demand for meat and milk. However, there were deficits based on population estimates for the following 15 years (127 million people). A shortage of 3.185 billion liters (29%) of milk and 1.3 million metric tons (535 of meat will exist by 2028. The annual demand for meat was around 24.5 kg per person since suffering a large decline in population at the beginning of the 1990s, Ethiopia's cattle population has increased significantly during the past ten years. However, there has only been a slight increase in dairy cattle and chicken meat yield per animal. In recent years, the amount of beef produced by cattle per animal (measured in kilos) has decreased, whereas the amount of meat produced by sheep and goats has stayed constant (Muller *et al.*, 2017).

The production and consumption of meat and milk per person have been steadily declining during the past few decades. The consumption of both livestock products has begun to rise, nonetheless, after 2000. The growth of the contemporary intensive commercial cattle sector is to blame for changes in export performance in terms of value. Despite the productivity decline shown above, the cattle industry has continuously increased its share of export revenue.

2.2 Constraints of Livestock Production in Ethiopia

The main barrier to livestock production, both in terms of quantity and quality, is nutrition (Takele *et al.*, 2014). Ethiopia's native livestock populations and breeds are able to survive the country's tough environmental circumstances. They frequently possess unique adaptive features for illness resistance, heat tolerance, and the capacity to consume subpar diet that they have evolved naturally over many generations (Azage *et al.*, 2010).

The availability of feed resources in the form of dry matter (DM), energy (ME), and cellulose (CP), as well as the needs of all

animal species, were compared (i.e., feed balance), and it was discovered that Ethiopia has a 9percent DM deficiency while ME and CP deficiencies are 45 and 42percent, respectively. These results show a lack of high-quality feeds in the nation (FAO, 2018).

2.2. Livestock Feed Sources in Ethiopia

According to CSA (2017/18), crop residue is Ethiopia's second-largest feed source after green fodder (approximately 55.96 percent) (30.12 percent). In addition to being utilized as animal feeds, hay and byproducts made up roughly 6.55 percent and 1.61 percent of all feeds, respectively. Animal feed only makes up 0.32 percent of the total amount of enhanced feed utilized in the nation; the remaining feed kinds make up roughly 5.44 percent. Crop residue and natural pasture alone account for more than 85percent of the aforementioned. Numerous publications claim that the aforementioned feed resources are accessible. According to Addis (2015), ruminants can be fed on cultivated forages, crop residues, natural pasture, industrial by-products, herbaceous forages produced from trees and shrubs, food crop residues, agro-industrial by-products, mineral supplements, and other by-products. The best animal feed sources of are local alcohol waste and agricultural left overs, next natural grassland and crop residues.

2.2.1. Natural pasture

The known feed source in Ethiopia, which provided about 54.54 percent of the country's feed was natural pasture, but it began to suffer from decline. CSA (2020/2021) determined that the productivity natural pasture ranged from 0.5 to 6 tons of DM per hectare (Tegene *et al.*, 2015). Noted that production substantially differs in a given grazing pasture in a given Kebele due to utility methods, slope for water flow, and nutrient erosion and retention.. The conversion of natural pasture into arable land, which was primarily granted to landless farmers, was the main reason for the fall in size (Berhanu *et al.*, 2009). The CSA (2017–18) also claimed that natural pasture is the main source of feed, but the much-desired increased forage cover is still only at 1%. According to Mergia *et al.* (2014) cropland is displacing natural grazing land due to an expanding tendency.

2.2.2. Crop residues

Crop residue's contributions to the nation's feed supply become significant. The trend showed that in Ethiopian conditions, intensively studied crop wastes might supply 40–50% of the annual livestock feed needs. Crop wastes like maize stover are crucial sources for animal feed. Due to its dual uses as a building material and an energy source, it did encounter certain difficulties. In actuality, the majority—nearly 70percent, according to (Mergia *et al.*, (2014)—were fed yearly. The authors claim that *Teff* straw experienced similar conditions, and they emphasize the significance of agricultural waste during the dry season (Abate *et al.*, 2010). Crop leftovers, however, are shown to have low levels of nitrogen, calories, minerals, and vitamins, as well as poor voluntary intakes (Alemu *et al.*, 1991). Crop residues' CP content ranges from 2.4 to 7 percent, while straw's IVDMD value is between 34 and 52%. However, depending on the type of crop employed, agricultural residues have different nutritional qualities (Daniel, 1988).

2.2.3. Agro-industrial by-products as animal feed

They consist of leftovers from the grinding of cereal and leftovers from the extraction of food oils, both of which are excellent sources of protein and easily fermentable energy, respectively. Some of the energy sources are wheat short, rice bran, screenings, and the by-products of milling (wheat bran, the rough outer coat of wheat, and wheat middling, the finer of the two, which may contain bran, endosperm, and germ). Edible oil processing by products such as Noug seed (*Guizotia abyssinica*) cake (NSC), cotton seed cake (CSC), linseed cake (LSC) and rapeseed (*Brassica carinata*) or Ethiopian mustard cake (RSC), groundnut, sesame, sunflower, peanut, sun flower cakes are considered as protein sources. In some amount molasses and spent brewery grain are some of agro-industrial by-products which support as energy sources. The traditional brewery residue (*Tella* and *Areqie*) liquor residue also the by-products produced by some brewery and liquor crops, respectively (Mesfin *et al.*, 2014). They quoted that wheat bran is the most widely by products adapted by farmers than other by- products.

2.2.4. Improved forage

For approximately 50 years, forage development techniques have been developed and introduced nationally. It began in the mixed-crop livestock production system in the 1970s Alemayehu and Getnet, (2012). The Fourth-Livestock Development Project (FLDP), where major emphasis started to be given, laid the groundwork for progressive development (1988-1994). The Agriculture Growth Program Livestock Market Production Project (AGPLMDP), which recently began, and the National Livestock Development Program (NLDP), which is renowned for its impressive investments in forage and forage seed development all included forage development in their efforts (ILRI, 2015a). Despite these efforts, the enhanced forages' (0.3) contribution to the national feed is still relatively low. Poor awareness, insufficient extension effort, a lack of improved forage seed, and a lack of region-specific research projects are some of the likely causes of low participation. From the study of (Dinku *et al.*,2017) indicated that the same oat forage which sown in different soil types which hold different cation exchange capacity, organic matter (percent), available phosphorus (mg/l) and total nitrogen percent) caused variation in biomass yield and nutrient content. Soil which hold better in nitrogen content and available phosphorus in one site cannot cause for better in CP content of the forage in that location because of other intricate factors.

2.2.5. Non- conventional feed sources

The term "non-traditional feed sources" (NCFS) refers to all feeds that are not generated in a conventional, typical, or commercial manner (Sontakke *et al.*, 2014). The authors list fish offal, duck weed, and leftover food from the kitchen (potato, carrot, and onion peels, leftover cabbage), poultry litter, algae, spirulina, and local brewery and distillery goods as non-traditional feed sources. For owners of small and medium-sized animals, non-traditional feeds such sisal waste; cactus, coffee, and banana pulp are also frequently utilized and may be accessible. They were used in a number of researches as supplements, particularly for small ruminant fattening. Dinku *et al.* (2017) conducted an experiment using sweet potato vine as supplement for sheep fattening and observed the average daily gain range between 72-106 g/day within 84 fattening days. This range was much higher than the

controlled group. In other study which conducted in Shebedino district, SNNPRS by Tegene *et al.* (2015) shown that more households adapted feeding by-products to their livestock in the district and was greater than the national as well as the regional level.

2.4. Feed Balance

The yearly potential biomass available for animal feeding in Ethiopia is 144.48 million tons, with embedded ME and CP of 890 x 109 MJ and 7.49 million tons, respectively. The fact that forages make up 96.6 and 92% of the total ME and CP availability suggests that concentrate feeds make up very little of the ME and CP. Cattle, sheep, and goats contribute 83.5, 4.7%, and 4.7 % of the total ME requirements at the national level, respectively, while the corresponding percentages for CP requirements are 79.5, 6.15 and 5.5%. The availability of feed resources in the form of dry matter (DM), energy (ME), and protein (CP), as well as the needs of all animal species, were compared (i.e., feed balance), and it was discovered that Ethiopia has a 9% DM deficiency while ME and CP deficiencies are 45 and 42%, respectively. These results show a lack of high-quality feeds in the nation (FAO, 2018).

3. MATERIALS AND METHODS

3.1. Description of Study Area

The study was conducted in Soddo district, East Gurage Zone, Central, Ethiopia. The district is about 103 kilometers south of Addis Ababa. Geographically, it is located at 8.08N–8.3N and 38–38.37E, with an altitude range of 1800–3040 m.a.s.l. The study area has an annual rainfall of 908.875 mm and an annual temperature range of 18 °C. The district has two agro-ecologies: mid-altitude (1800-2300 m.a.s.l) (65 percent of total district area) and highland (above 2300 m.a.s.l) (35percent). Topographically, the district comprises 40, 23, 7, and 7 percent plains, ups and hills, ranges, and mountains, respectively. The total area of the district is 684.7 square kilometers. The total population of the district was 77308 males and 76848 females. Among the population, 93.5% are rural, and the rest (6.5%) are urban residents. About 47 % of the rural and 48 % of the urban are male while the rest (53 %) of rural and 52 percent of the urban are female. The total households in the district are 29718. The district has 7 municipal and 35 rural Kebeles (peasant associations) among which 12 Kebeles are located at high altitude (*Dega*) and the rest are mid-altitude (*Weyna Dega*) (SWPDO 2024).

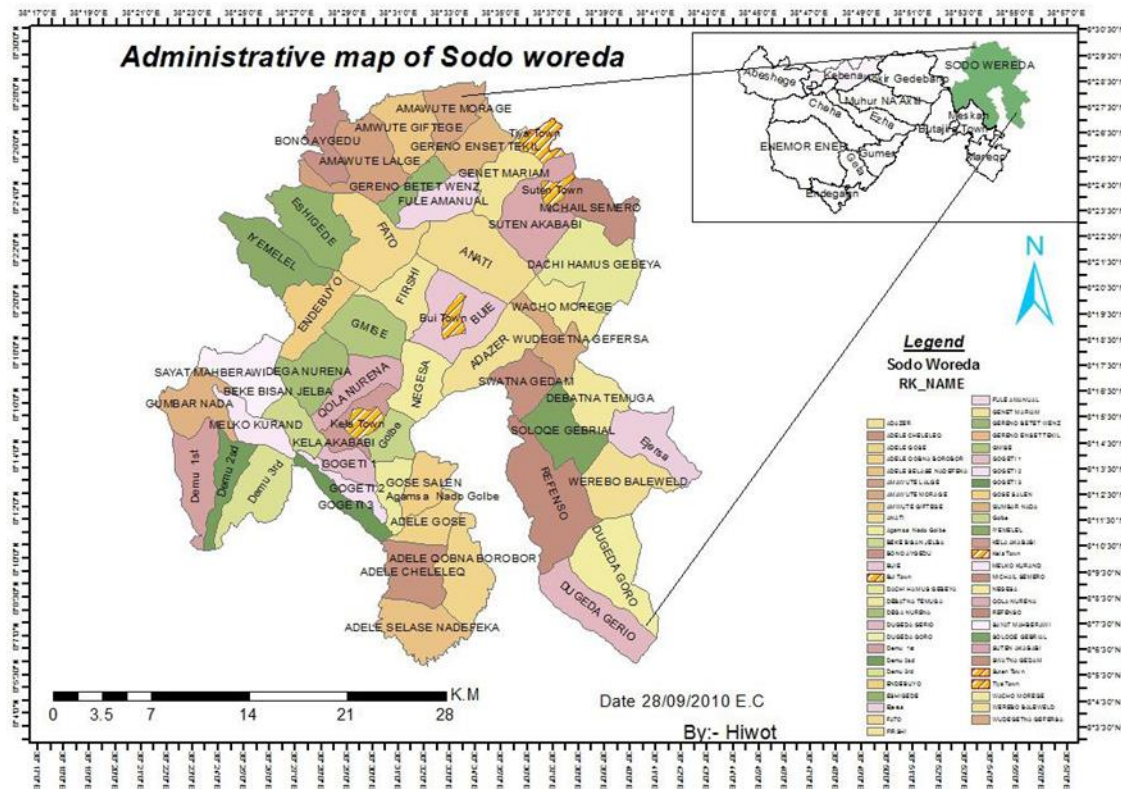


Figure 1 Map of the study area

3.2. Sampling Techniques and Sample Size Determination

The study was conducted in 14 kebeles of sodd district. The kebeles were selected purposively based on cattle potential and accessibility. Stratified sampling procedure was used to select representative kebeles and household heads. The kebeles of the district were stratified in to highland and midland agro-ecological zones based on the altitudinal difference. Thus, kebeles which are found at an altitude of >2300 m.a.s.l were grouped in to highland while kebeles found at an attitude range of 1500-2300 m.a.s.l

were grouped in to midland. Five representative kebeles (Amawute Giftige, Gereno Betet Wenz, fatto, Genete Maryam and Eshkede) from Highland and Nine kebeles (Anati, Firshi, Buee Zuria, Semero, Adazer, Wudegetena Gefersa, Soloke, Adele Silasie and Dugida Goro) from Midland agro-ecological zone were selected based on livestock production potential and accessibility purposively with the consultation of district livestock production experts and development agents. Representative household heads were selected randomly for the interview using Probability Proportional to Size (PPS) based on the population of each kebele. The sample size was determined by using Yamane (1967) formula. The total target population of the study area was estimated to be 5923.

$$n = \frac{N}{1 + N(e)^2}$$

Where;

N = Population size (5923)

n= sample size (376)

e = expected error (5%)

3.3. Sources of Data and Methods of Data Collection

Primary and secondary data were collected. The primary data was collected by using semi-structured questionnaire interview and field observations. The semi-structured questionnaire was pretested to check the appropriateness and clarity of the questions before the commencement of the actual data collection. Secondary data was collected from different documents of the district, articles, books and internet. The questionnaire used in the study was designed focused on the following information: household demography, farm size, land use pattern, herd size, herd composition, breed type, purpose of livestock raising and, major crops grown, crop grain yield, types of livestock feed, feeding and housing system of livestock, and feed markets, and quantity of total feed available for livestock, major livestock diseases, available livestock health services and associated problems, water access and types of livestock health service organizations.

3.4. Estimated Annual Feed Supply

The quantity of dry matter from natural pastures was determined by multiplying the hectare of land under each land use category by their respective estimated annual DM yield per hectare i.e. 2.0 t/ha (FAO, 1987). The amount of purchased dry forages such as hay and straw, if any, was determined by estimating the amount based on given information from the respondent households and for baled hay by asking how many bales of hay would be purchased for a year. The quantity of available crop residues produced by farmers was estimated by applying grain to straw ratio as suggested by FAO (1987). Accordingly, for a ton of wheat, barley, oat and teff straw, a multiplier of 1.5; for faba bean, field pea, and haricot bean straw a multiplier of 1.2; for maize a multiplier of 2.0, and for sorghum a multiplier of 2.5 was used. The quantity of potentially available crop residues for animal consumption was estimated by assuming 10% wastage (Adugna and Said, 1994). The amount of grain yield obtained from the respective crops was quantified by interviewing the farmers and by cross checking the data recorded by development workers and the respective offices for any deviation. The assessment of dry feed quantity and potentially available crop residues was taken from 2023 September to March 2024. The quantity of concentrates and non-conventional feed resources was estimated by interviewing the households with regard to frequency and quantity purchased per month. The grazing potential of crop stubbles was estimated using a mean of 0.5 ton per hectare of land as reported by FAO (1987). Utilization factor of 75% as suggested by Woody Biomass Inventory and Strategic Planning Project (WBISPP, 2002) for extensive grassland was used to quantify the DM that would be utilized by livestock. The feed DM from enset leaf and leaf midribs used for animal consumption was estimated by assuming a mean of 8 ton per hectare of enset garden (FAO, 1987) as cited by (Dirsha, 2019).

3.5. Estimated Annual Feed Requirement

The annual availability of feed was compared with the annual requirements of the livestock population. Livestock populations were converted in to Tropical Livestock Unit (TLU) as suggested by Gryseels (1988) for indigenous zebu cattle and Bekele (1991) for crossbreds. The dry matter (DM) requirements for maintenance was calculated based on daily DM requirements of a 250 kg

dual-purpose tropical cattle (an equivalent of one TLU). Nutrients supplied by each feed types was estimated from the total DM output and nutrient contents of that feed on DM basis (Abdinisir, 2000). The total nutrient requirements (DM, crude protein (CP) and Metabolizable energy (ME)) per day per TLU was estimated based on recommendations of Kearl (1982) and McCarthy (1986) for tropical livestock unit.

3.6. Chemical Analysis of Feed Samples

Laboratory analysis of feeds was done at Jimma Univerity Collage of Agriculture Nutrition Lab. Dry matter (DM) contents of feed samples were determined by oven drying at 105°C for 24hrs (AOAC, 1990). An ash content of feed samples was determined by igniting the sample in a muffle furnace at 550-600°C for 6 hours (AOAC, 1990). Nitrogen (N) content was determined by Kjeldahl method and Crude Protein (CP) was calculated as $N*6.25$ (AOAC, 1995). Acid Detergent Fiber (ADF), Acid Detergent Lignin (ADL), Neutral Detergent Fiber (NDF), and In vitro Organic Matter Digestible (IVOMD) were determined by the method modified by Tilley and Terry method (Van Soest and Robertson, 1985). Metabolizable Energy (ME) and Digestible Crude Protein (DCP) contents of a particular feed were estimated from IVOMD and CP contents, respectively, as per the following equations:-

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

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

3.7. Data-Analysis for Survey Study

Statistical analysis of collected data was done using statistical Package for Social Sciences (SPSS) software, version 20 (SPSS, 2011). Descriptive statistics such as means, frequency distribution, figures and percentages were used to disclose the results. General linear model was used to analyze the relation between dependent and independent variables. Tukey test was applied to examine the existence of differences between levels of significance of feed resource between agro-ecology and season. Chi-square

was used to test differences between highland and midland agro-ecologies. Statistical significance between variable was determined by using P-value at critical point of ($P < 0.05$) and index calculation was used to rank constraints by the formula of:

Formula for ranking:

$$\text{Index} = \frac{R_n * C_n + R_{n-1} * C_{n-1} + \dots + R_1 * C_1}{\sum R_n + C_1 = R_{n-1} * C_2 \dots + R_n * C_n}$$

Where;

R_n = value given for the least ranked level (example, if the least rank is 5th, then $R_{n-1} = 4$, and $R_1 = 1$);

C_n = count of the least ranked level (in the count of the 1st rank = C_1).

Model for survey

$$Y_{ij} = \mu + P_i + e_{ij}$$

Where;

Y_{ij} = the response of dependent variable

μ = overall mean

P_i = the effect of agro-ecologies (i = milk yield, lactation length, calving interval, days open and dry matter yield)

e_{ij} = random error

Model for feed chemical analysis

$$Y_{ij} = \mu + A_i + e_{ij}$$

Where;

Y_{ij} = observed variable

μ = Overall mean

A_i = agro-ecology effect (i = DM, CP, ASH, OM, EE, NDF, ADF, ADL, DCP, IVDMD, ME (MJ/kg DM))

e_{ij} = Random error

4. RESULTS

4.1. Household Characteristics

The household characteristics of the study area is presented in Table 1. The proportion of male household heads (96.8%) was higher than female household heads (3.2%). This might indicate that males are more involved in the livestock production. Regarding to the age grouping, majority of respondents(47.0%) age of 41-60,(44.5%)age of21-40 and61-80(7.8%) were at the age of 41-60 years and followed by 21-40 and 61-80 years, respectively. This result showed that about 92% of the respondents were at the age of 21-60 years which is good opportunity towards obtaining workable labour power in the areas of agriculture in general and in animal husbandry in particular. However, there was significant difference ($P < 0.05$) between the two agro-ecological zones in terms of age categories. Majority of the sample households (85.1%) in both agro ecologies of the study areas had opportunities of getting different level of education. Conversely, about 18.02% of households in the highland agro ecology and 11.7% in the midland areas did not have access to educational opportunities, resulting in illiteracy. In contrast, 81.91% of the farmers in the highlands and 88.29% of households in mid-altitude areas were able to access education (Table 2). The educational level showed significantly difference ($P < 0.05$) between the two agro-ecologies. This variation might be associated with accessibility to schools. The overall marital status of the respondents in the current study showed that majority of them (96.8%) were married while the rest (3.2%) were unmarried. Marital status didn't show significant ($P > 0.05$) variation between the two agro-ecological zones. The cattle production system in the study area was identified as mixed crop-livestock production system which was characterized by production of livestock and cereal grains including Wheat, Barley, Bean, Pea and Enset (*Ensete ventricosum*) in both agro-ecologies of the study areas. The overall family size of the study area was 6.72 ± 0.20 . The average family size in the highland was 5.82 ± 0.19 while it was 7.63 ± 0.21 in the midland. Out of the total population in the study area, about 47.47% was male and the other left (52.53%) was female.

Table 1 Household characteristics of the study area in highland and mid agro-ecological

Characteristics		Agro-ecology				Overall		χ^2 - value	p- value
		Highland		Midland					
		(n =71)	%	(n =95)	%	(N= 166)	%		
Sex	Male	69	95.8	93	97.8	161	96.9	1.38	0.19
	Female	3	4.2	2	2.2	5	3.1		
Age/year	21-40	26	36.6	48	50.5	74	44.5	7.50	0.02
	41-60	38	53.5	40	42.1	78	47.0		
	61-80	7	9.8	6	6.3	13	7.8		
Educational level	Illiterate	13	18.3	11	11.5	24	14.4	27.68	0.00
	Read & write	29	40.8	20	21.05	49	29.5		
	Primary	20	28.1	40	42.1	60	36.1		
	Junior school	6	8.4	15	16.0	21	12.6		
	High school	6	2.2	6	6.3	12	7.2		
	> high school	1	1.4	2	2.1	3	1.8		
Marital status	Married	68	95.7	93	97.9	161	96.9	1.37	0.19
	Unmarried	3	4.3	2	2.1	5	3.1		
Farming system	Livestock production	3	4.3	4	4.2	7	4.2	1.64	0.17
	Crop production	-		-		-	-		
	Mixed	68	95.7	91	95.8	159	95.8		

production								
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N=number households; n = number of households in each agro-ecological zone

4.2. Landholding and Land Use System

The average landholding (ha) per HH and land use pattern in the study area is indicated in Table 3. The overall landholding of the study area was 1.29±0.375 ha. The total landholding per household in the highland agro-ecology was significantly (P< 0.05) higher than that of the midland and the largest part of the land was allocated for annual crop production followed by grazing land in both agro-ecologies.

Table 2 Average landholding/HH and land use pattern in the study area of soddo district (Mean±SD)

Variables	Agro ecology			P-value
	Highland(n=71)	Midland(n=95)	Overall(N=166)	
Total land(ha)	1.32±0.05	1.26±0.25	1.29±0.38	0.04
Crop land	0.9±0.50	1.15±0.25	1.03±0.38	0.02
Enset	0.25±0.01	0.065±0.01	0.17±0.01	0.01
Grazing land	0.10±0.03	0.004±0.02	0.052±0.02	0.000
Forest land	0.003±0.14	0.004±0.02	0.003±0.08	0.002
Fallow land	0.02±0.0	0.02±0.01	0.02±0.01	0.003
Home stead land	0.05±0.02	0.02±0.17	0.035±0.06	0.001
Land allocated for annual crops(ha)				
Wheat	0.25±0.13	0.15±0.05	0.20±0.04	0.000

Barley	0.125±0.05	**	0.065±0.02	
Teff	0.25±0.05	0.25±0.04	0.25±0.04	0.000
Maize	0.25±0.00	0.625±0.03	0.44±0.02	0.000
Bean	0.01±0.01	0.025±0.00	0.02±0.00	0.000
Pea	0.02±0.01	0.01±0.00	0.01±0.00	0.000
Sorghum	**	0.01±0.00	0.005±0.00	0.000

^{b-a} = means in the same row with different letter of superscripts are significantly different ($P<0.05$), **= not grown in the area, HH=household, ha = hectare

4.3. Estimated Crop Residues

Crop residues production in study area is indicated in Table 4. From the result of current study, it is clear that the types of Crop residues production were limited in number. This could limit the amount of produced crop residues for livestock feeding in both agro ecologies of the study areas. Bearing the difficulties of provision of cultivable land in mind, the use of appropriate agricultural technologies and environmental challenges were other bottlenecks in bringing improvement in the production and productivity of lands available in the area. The major annual crops grown in highland agro-ecology of the study areas of Soddo district in East Gurage zone were wheat straw, barley straw, bean straw, pea straw and partially teff straw. Whereas wheat straw, teff straw and maizestover took the highest rank of production in midland agro ecology of the study area. Consequently, the biomass of wheat and barley straw were the largest among other straw residues produced in highland. The crop residues of wheat, teff and maize encompass the largest portion of crop residues produced in midland agro ecology.

Table 3 Annual field crop yield and crop residues in tons per HHs in the study area of sodd district of Gurage zone (mean \pm SD)

Type of crops Straw	Agro ecology			P- Value of straw
	High land(n=71)	Mid land(n=95)	Over all(N=166)	
Wheat Straw	3.63 \pm 0.38 ^b	5.77 \pm 0.38 ^a	4.71 \pm 0.3	0.01
Barley Straw	2.31 \pm 0.36	**	1.16 \pm 0.1	
Teff Straw	0.39 \pm 0.38 ^b	2.61 \pm 0.17 ^a	1.5 \pm 0.27	0.00
Maize Stover	5.7 \pm 0.24 ^b	8.55 \pm 0.21 ^a	7.13 \pm 0.2	0.01
Bea Straw	0.44 \pm 0.28 ^a	0.06 \pm 0.12 ^b	0.30 \pm 0.1	0.00
Pea Straw	0.25 \pm 0.39 ^a	0.02 \pm 0.11 ^b	0.16 \pm 0.19	0.003

^{b-a} = means in the same row with different letter of superscripts are significantly different ($P < 0.05$), ** = not grown in the area,

HHs = household

4.5. Livestock Management

4.5.1. Types of Livestock Feeds and Feeding System

Major feed resources available in the soddo district were indicated in Table 7. In highland and midland agro ecologies of soddo district cattle production system is characterized by extensive system of production. Households in the study areas largely depend on feeding of crop residue and natural pasture. According to the results obtained from current study, the common crop residues available in the district were maize stover, wheat straw, teff straw, and barley straw. Even though it was not insignificant in number some of households in the study area feed their animals on crop weeds for their animals during the main rainy season to supplement the inadequate feed supplies from grazing.

Enset leaf and leaf midribs was also used as animal feed in highland agro ecology during long dry season to supplement the inadequate feed supplies from natural pasture and crop residue. In this regard, *Ensete ventricosum* is not commonly used as animal feed source and the households in the study areas are entirely focused on production of enset as human food source. In both highland and midland agro ecologies of the study areas households largely depend on grazing lands and crop residues to feed their livestock. Based on the responses of interviewed HHs (Table 7) about 43% and 57% from high land and 72% and 28% from midland agro ecology had a practice of individual and group feeding system, respectively

Table 4: Major livestock feed resource and feeding system in the study area

Feed resources	Agro ecology					
	Highland (71)		Midland (95)		Overall	
	n (index)	Rank	n (index)	Rank	N (index)	Rank
Natural pasture only (NP)	1(0.01)	5	1 (0.005)	4	3 (0.007)	5
Crop residue only (CR)	**	**	6(0.064)	3	11(0.031)	4
Industria by product(IBP)	**	**	**		**	
Enset only	1 (0.01)	4	**	**	2 (0.005)	6
NP &CR	9(0.127)	2	21(0.228)	2	65(0.178)	3
NP, CR & IBP	7(0.10)	3	67(0.702)	1	147 (0.402)	1
NP, CR, IBP & Enset	53(0.75)	1	**	**	137(0.375)	2
Feeding system in %	%		%		%	
Individual feeding	43		72		57.5	
Group feeding	57		28		42.5	

IBP=Industrial byproduct, NP=Natural pasture, CR= Crop residue n = number of households per agro ecology, N = total number of households in the study

4.5.2. Feed Conservation Practice

In the study area of Soddo District, the major conserved feed resources were crop residues. Collection and storage of crop residues start soon after crop harvesting. In the high land agro ecology, almost all respondents stored collected crop residues in temporary shelter with a roofing. On the other hand, in midland agro ecology all interviewed respondents heaped the residues in conical shape with roofless shelter (fencing) made of local materials to reduce damage by animals and other calamities.

4.6. Chemical Composition and Nutritive Value of Feed

Table 8 shows the nutritional value (DCP (g/kg), IVDMD% ME (MJ/kg DM%), and chemical composition (DM%, Ash%, CP%, EE%, NDF%, ADF%, and ADL%) of the primary feed stuffs (maize stover, wheat straw, enset, teff straw, natural pasture, and barley straw) in the research region utilized for Livestock feeding. In the highland, the dry matter (DM) content of all feeds that were accessible for feeding cattle varied from 90.43% in wheat straw to 92.53% in enset, whereas in the midland agro ecology, it was varied from 91.12% in wheat straw to 92.87% in maize Stover and natural pasture. Barley straw had a dry matter (DM) content of 92%, whereas natural pasture on the highlands had a DM content of 91.23%.

The crude protein (CP) content of crop residues varied from 3.56 % in wheat straw to 9.07% in barley straw for high land and 3.09% in wheat straw to 5.87% in teff straw for midland agro-ecology. The CP value (9.92%) in high land and (8.19%) in midland was obtained from natural pasture. The CP content of natural pasture was higher in high land agro-ecology than in midland agro-ecology. The CP value (8.51%) obtained from enset leaf and leaf midribs were higher than the minimum CP value (7%) required for optimum rumen microbial function. The ash content of crop residues in the study area ranged from 9.11% barley straw to 9.22% wheat straw in the highlands and 9.09% teff straw to 9.37% wheat straw in the midlands. The ash content of natural pasture is 10.11% in the highlands and 11.47% in midland agro-ecology, respectively. The organic matter content of feed stuffs ranged from 88.53 percent natural pasture in mid-land to 92.83% enset in high-land, in which the enset leaf had the highest (92.83%). The organic matter content of crop residue ranges from 90.78% wheat straw to 90.89% barley straw in high land and 90.03% maize stover to 90.91% teff straw in mid-land agro-ecology.

The fat content (EE) of feed stuffs ranged from 0.27% wheat straw to 6.84% enset in highland, where enset had the highest EE content (6.84%). The (EE) contents of crop residues in midland are maize Stover (0.47%), wheat straw (0.76%), and teff straw (2.75%). The EE content of natural pasture in midland (1.9%) and high land (1.56%).

The neutral detergent fiber (NDF) content of the straws of cereal crops in the current study was between wheat straw (64.83%) and teff straw (75.21%) in midland and barley straw (51.25%) in high land agro-ecology. The neutral detergent fiber (NDF) content of natural pasture is 75.93% in high land and 76.64% in midland agro-ecology. The neutral detergent fiber (NDF) content of maize stover is 77.35% in mid land and ensset leaf is 61.82% in high-land agro-ecology. The ADF content of crop straws varied from 51.6% in barley straw to 67.12% in wheat straw on high land. And teff straw 58.44% to 63.33% wheat straw in mid land agroecology. Whereas the ADF content for native grass in the high land and mid land agroecologies, respectively, was 51.02 and 43%.

The ADF percentage in maize stover in the study area was found to be 53.44% in midland, while the percent ADF in ensset was 53.5% in highland agro-ecology. The acid detergent lignin (ADL) contained in different crop residues found in the study areas ranged from 7.52 % wheat straw in midland to 8.6% barley straw in highland agro-ecology. The highest concentration of lignin was found in barley straw (8.6%), followed by teff straw (8.53). The lignin percentage in the maize stover of the study area was found to be 8.11, while the percent lignin of native grasses in the High land and Midland agro-ecologies, respectively, was 8.93 and 9%, which is greater than the limiting lignin content of 7%.

The ADL in the leaf of ensset (*E. ventricosum*) in the current study was 9.71%, which is higher than the maximum level of 7%. The digestible crude protein (DCP) content of natural pasture in the current study was 88.68% (g/kg) in high land and 72.6% (g/kg) in midland agro-ecology. Whereas the digestible crude protein (DCP) content of crop residues in the current study ranged from 25.23% (g/kg) for wheat straw in midland to 80.78% (g/kg) for barley straw in highland agro-ecology. The digestible crude protein (DCP) value reported for the leaf and leaf midribs of *ensset* (*E. ventricosum*) from highland areas of the study was 75.58%(g/kg) The digestible crude protein (DCP) value reported for maize stover from the midland area of the study was 35.54% (g/kg).

The IVDMD reported in the current study for natural pastures was 59.19% and 59.93% in highland and midland agro-ecologies, respectively. The IVDMD for maize stover reported

in the current study was 54.53%. The level of IVDMD from the leaf and leaf midribs of the enset in the current study was about 57.16%. The IVDMD content of crop residue ranged from 52.23% to 56.3%, with Teff straw having the highest (56.3%). The IVDMD content reported for wheat straw was 54.04% in highland and 52.23% in midland agro-ecology (Table 16), which was lower than all reported IVDMD values of crop residues in the current study. The level of IVDMD in the leaf of the enset was about 57.16%. The IVDMD of straws from cereal crops ranged from 52.23 to 56.3% with teff straw having the highest (56.3%) content, followed by barley straw (54.12%).

The metabolic energy (ME) content of natural pasture in the current study was 8.88 MJ/kg DM in high land and 8.99 MJ/kg DM in midland agro ecology. The energy content of crop residues in the current study ranged from 8.11 MJ/kg DM for wheat straw to 8.45 MJ/kg DM for teff straw. The energy value reported for the leaf and leaf midribs of *enset* (*E. ventricosum*) from highland areas of the study was 8.57 MJ/kg DM.

Table 5: Chemical composition and nutritive value of feed in study area of soddo district

Feed Stuffs	Agro Ecology	Chemical composition of feed stuffs								Nutritive value of feed stuffs		
		DM%	CP%	ASH%	OM%	EE%	NDF%	ADF%	ADL%	DCP(g/k)	IVDMD%	ME (MJ/kg DM)
Natural Pasture	Highland	91.23	9.92	10.11	89.89	1.56	75.93	51.02	8.93	88.68	59.19	8.88
	Midland	92.87	8.19	11.47	88.53	1.9	76.64	43	9	72.6	59.93	8.99
Wheat Straw	Highland	90.43	3.56	9.22	90.78	0.27	67.49	67.12	8.02	29.59	54.04	8.11
	Midland	91.12	3.09	9.37	90.63	0.76	64.83	63.33	7.52	25.23	52.23	7.83
Barley Straw	Highland	92.22	9.07	9.11	90.89	2.01	51.25	51.6	8.6	80.78	54.12	8.12
	Midland	**	**	**	**	**	**	**	**	**	**	**
Teff Straw	Highland	**	**		**	**	**	**	**	**	**	**
	Midland	92.57	5.87	9.09	90.91	2.75	75.21	58.44	8.53	51.05	56.3	8.45
Maize Stover	Highland	**	**	**	**	**	**	**	**	**	**	**
	Midland	92.87	4.2	9.97	90.03	0.47	77.35	53.44	8.11	35.54	54.53	8.18
Enset	Highland	92.53	8.51	7.17	92.83	6.84	61.82	53.5	9.71	75.58	57.16	8.57
	Midland	**	**	**	**	**	**	**	**	**	**	**

DM = Dry matter, CP = Crude protein, OM = Organic matter, EE = Ether extract, NDF = Neutral detergent fiber, ADF = Acid detergent fiber, ADL= Acid detergent lignin ** = not available in the Study area

4.7. Estimated Annual Feed balance

Estimated annual nutrient supply of feed stuffs in highland and mid altitude agro ecology in the study area used for cattle feeding is indicated in Table 9. The annual nutrient supply of DCP of wheat straw, barley straw men's and natural pasture (6.9 kg, 17.59 kg, 16.5kg and 19.24kg) respectively in high land agro-ecology and the annual nutrient supply of DCP of wheat straw, maize Stover and natural pasture were 8.97kg, 17.04kg, 12.19kg and 23.76kg, respectively in midlandland agro ecology. The annual nutrient supply of dry matter of wheat straw (483.80 ton) and natural pasture (12.54 ton) in the high land area comparable from the annual nutrient supply of dry matter of wheat straw (494.21ton) and natural pasture (10.45ton) from midland agro ecology and also nutrient supply of TME (MJ) of wheat straw (3,348,218.85 MJ) and natural pasture (86,785.17 MJ) in the high land area which was significantly different ($P < 0.05$) from the annual nutrient supply TME of wheat straw (3,632,585.94 MJ) and natural pasture (76,810.51 MJ) from midland agro ecology. The total annual nutrient supply of DCP (60.23 kg), Dry Matter (1333.30 ton) and TME (9,227,325.74 MJ) in the high land agro ecology whereas the annual nutrient supply of DCP (61.96 kg), Dry Matter (1795.48 ton) and TME (13,197,295.5 MJ) in the midland agro ecology. The total estimated nutrient supply, requirement and feed balance in the district are indicated in Table 9.

In the highland agro ecology, the estimated available feed supply satisfies only about 68.9 %, 44.83% and 69.46% of the maintenance level of DM, DCP, ME requirement of animals per year. In the midland agro ecology, on the other hand, the amount of feed dry matter available only serve for 79.7% of total maintenance requirement of animals found in the study areas. In the same way, total annual DCP and ME produce in the study areas, respectively; satisfy 39.36 % and 83.36% of the total requirements of animals found in midland areas of the study. The negative balance observed in the district resulted from shortage and poor quality of roughages as well as unavailability of byproducts shortage of supplement feeds.

Table 6 Estimated annual DM and nutrient supply of feed stuffs in the highland and mid altitude agro ecology in the study area of sodd district in East Gurage zone.

Feed stuffs	Agro ecology						P-value
	High land			Mid land			
	DCP(kg)	DM(t)	TME (MJ)	DCP(kg)	DM(t)	TME (MJ)	
Wheat	6.90 (11.45%)	483.80 ^a (36.28%)	3,348,218.85 (36.28%)	8.97 (14.48%)	494.21 ^b (27.52%)	3,632585.94 (27.52%)	0.04
Barley	17.59 (29.2%)	400.49 (30%)	2,771,658.06 (30%)	**	**		0.00
Teff	**	**		17.04 (27.5%)	454.22 (25.3%)	3,338,647.92 (25.3%)	0.00
Maize	**	**		12.19 (19.67%)	836.60 (52.16%)	6,149,251.13 (46.59%)	0.00
Enset	16.50 (27.39%)	436.47 (32.75%)	3,020,663.66 (32.74%)	**	**		0.00
Natural pasture	19.24 (31.94%)	12.54 a (0.92%)	86,785.17 (0.94%)	23.76 (38.35%)	10.45 b (0.58%)	76810.51 (0.58%)	0.03
TOTAL	60.23(kg)	1333.30(t)	9,227,325.74(MJ)	61.96(kg)	1795.48(t)	13197295.5(MJ)	

^{b-a} = means in the same row with different letter of superscripts are significantly different ($P<0.05$), ** = not grown in the area, HHs = households, TME=total metabolism energy ,DCP=Digest able crude protein, DM=dry matter

Table 4 Estimated annual nutrient supply, requirement and balance of animals in the study area of sodo district East Gurage zone

Livestock in TLU in Agroecology	Annual nutrient supply			Annual nutrient demand			Annual nutrient supply and demand balance		
	TDM(t)	TDCP(t)	TME (MJ)	TDM(t)	TDCP(t)	TME (MJ)	TDM(t)	TCP(t)	TME (MJ)
Highland = 1220.9	1333.3	60.23	9,227,325.74	1935.13	134.35	13,284,373.4	-601.83	-74.12	-4057047.6
Amawute = 640.4	734.57	33.17	5,058,563.45	1015.03	70.47	6968066.76	-280.46	-37.3	-1909503.31
Esheged=580.5	598.73	27.06	4,168,762.29	920.1	63.88	6316306.61	-321.37	-36.82	-2147544.32
Midland = 1569.2	1795.48	61.96	13197295.5	2252.8	157.42	15,852607.2	-457.32	-95.46	-2655311.72
Dugeda =432.2	517.29	17.82	3802117.44	620.48	43.38	4366235	-103.19	-25.56	-564117.56
Adlesilasie=362	422	14.56	3101910.32	519.7	36.32	3657050.6	-97.7	-21.76	-555140.29
Soloke =393	440	15.18	3189507	564.2	39.43	3970223.5	-124.2	-24.25	-780716.45
S	416.19	14.35	3103759.93	548.41	38.32	3859097.6	-132.22	-23.97	-755337.67

TDM = total dry matter, TDCP = total digestible crude protein, TME = total metabolizable energy, MJ = mega joule, (t) = ton

5. DISCUSSIONS

5.1. Demographic Characteristics of Households

According to the results obtained from this study, the proportion of male to female households in the highland areas were 95.75% male, 4.25% female. Whereas the percentage of households in the midland areas of the study were about 97.87% male and 2.13% female with the overall average of about 96.81 % male and 3.19% female households in the current study. This result was relatively comparable with the results of 84.62% male and 15.38% female headed household reported by Gatwech (2012) in Gambella, south west Ethiopia, and 83.6% male and 16.4% of female headed households reported by Dirsha (2019) in Gurage zone southern Ethiopia. However, the overall average results of households 96.81% male and 3.19% female obtained in the current study is different from results of 67% male and 33% female reported by Azage (2004) in Addis Ababa; 75.6% male and 24.4% female headed households reported by Megersa (2016) in west Shoa zone of Oromia, Ethiopia. The difference shown between male and female household in the study areas might be related with cultural conditions that promotes the power of ownership of male household over the female family holding.

The results of the current study indicated that the majority 96.81% of the household respondents were married and about 3.19% single. The result obtained in the current study was relatively comparable with the values of 97.4% married, 1.3% single and 1.3% divorced reported by (Bernabas *et al.*, 2018) for Quara Districts in Northern Ethiopia. The average age of the HHs within the age interval of 21-80 years was 43.5 ± 0.9 which is similar with the average age of 43.4 ± 1.0 reported by Seid and Berhan (2014) in Burji Woreda, Segen Zuria Zone of SNNPRS, Ethiopia. This result has indicated that majority of the household were at the productive age groups and can manage their cattle. The result of current study on the educational status HHs is closed that 85.1% of the respondents had an opportunity of getting education which was relatively comparable with the values of 80.8% reported by Nigussie (2006) but

higher than the result of 40% reported by Ketema (2014) in Kersa Malima Wereda. However, the level of education of HHs reported in current study was lower than 90% reported by (Beriso *et al.*, 2015) in Aleta Chukko District, Southern Ethiopia. Adoption of technology particularly dairy was associated with the level of farmers' education. It could be said that dairy smallholder farmers with higher education level were more likely to accept training on dairy management, including herding, feed collection, feeding, milking, milk processing, health management and breed improvement. The overall mean family size per household in study areas was 6.72 ± 0.20 which was similar to the family size of 6 persons per household reported by (Abebe *et al.*, 2014) in Ezha Districts of Gurage Zone, Southern Ethiopia and 6.07 person per household reported by (Misgana *et al.*, 2015) in East Wollega Zone, Ethiopia but lower than 7.71 family size per HH reported by Dirsha and Dilla by (Sintayehu *et al.*, 2008). In the district, having greater number of children probably associated with wealth status of households with the assumption of realizing different activities of livestock and crop production.

5.2. Landholding and Land Use System

The average land holding per household was 1.32 ± 0.5 ha in highland and 1.25 ± 0.25 ha in midland agro ecology. The overall average land holding in the study area, was 1.29 ± 0.375 ha which was lowest when compared with 2.91 ± 0.18 ha reported by (Andualem *et al.*, 2015) in Essera Woreda, Dawuro Zone, Southern Ethiopia and 2.7 ha was reported by Asaminew and Eyassu (2009) in North western highlands of Ethiopia. However, the reports of current study on the land holdings per HH was similar with 1.015 ha reported by Ayalew (2017) in south Wollo Zone Amhara region Ethiopia, 0.9 ha reported by (Abebe *et al.*, 2014) in Ezha districts of the Gurage zone southern Ethiopia and lower than 2.5 ha reported for the Dendi District in Oromia Region by (Belay *et al.*, 2012).

5.3. Livestock feed Management

5.3.1. Types of Livestock Feed Resources and Feeding System

The availability of feed resources in the study area depends on the season. However, crop residues, and natural pasture in most cases in mid-altitude were commonly used as cattle feed resources in the study areas. In addition to the other mentioned feed resources, feed from enset leaves and leaf midribs has been another opportunity to feed animals in the study area of highland agro ecology. The result of the current study is comparable to the result of Getu (2019), who reported that roughages including natural pasture, grass hay, crop residues, and non-conventional feed resources are feed resources for dairy animals in Sebeta, Bedele, and Debre-Berhan areas.

5.4. Chemical Composition and Nutritive Value of Feeds

The chemical composition and nutritive value of the major feedstuffs utilized for cattle feeding in the study areas were indicated in Table 8. Dry matter (DM) content of the feeds available for livestock feeding in both highland and mid altitude agro-ecologies was above 90%, which corresponds with the reported results of different scholars in different parts of the country Ahmed (2006) and Sisay (2006). The dry matter (DM) content of all feeds available for cattle in the district was 90.43–92.87 %, which is similar to the results of 92.40%–94.03% Dirsha (2019) in the Gurage Zone of southern Ethiopia and Zewdie (2010) in the central Rift Valley.

The ash content of the major cereal crop residues in the study area ranged from 9.09% teff straw to 9.97% maize Stover midland, in which the maize Stover had the highest ash content 9.97% in midland, followed by wheat straw 9.37% in highland agro-ecology Table 8. The ash content reported for barely straw in this study was lower than the value 14.6% reported by Yitaye (1999) and Solomon (2004), but similar to the value 9.11% reported by Mekuanint and Girma (2017). On the other hand, the value of ash content for wheat straw 9.37% was similar to 9.34% reported by Mekuanint and Girma (2017), but higher than 8.94% reported by (Alemu *et al.*, 1989) and 8.22% reported by Solomon (2004). The ash content of the maize Stover recorded in this work 9.97% is far greater than the result reported by Yitaye

(1999), which was 7%. The variations observed in the ash contents of crop residues of cereal crops could be associated with environmental factors such as rainfall, soil character, temperature, and contamination of the residues by other external factors. The ash content of native grasses was 10.11% for highland and 11.47% for midland agro-ecology (Table 8). The variation observed could possibly be due to variation in the agro-ecology of the study areas, which corresponds with the report of Little (1982), who stated that the ash content of natural grasses increases as elevation in altitude

Decreases and such variations could possibly arise from differences in climate and soil types. However, Mekuanint and Girma (2017) reported 10.99% ash content of native grasses from highland and 9.89% from mid altitude which disagreed with the statement made by Little (1982) and the results recorded in the current study.

In general, except for barley straw, the percentage of CP obtained from crop residues that are considered available feed resources for livestock feeding in the study areas is much lower than that set as a minimum level of nitrogen 7% to limit intake Milford and Minson, (1966) Van Soest, (1982). The CP content reported in the current study from the same residues of crops (Table 8), however, is at a lower level to fulfill the optimum CP requirement of livestock, which agreed with the general statement made by Preston and Leng (1984), which indicated that some cereal crop residues have a low nitrogen content and are composed of cell wall components with little soluble cell contents. Grasses from the highland and midland agro-ecologies of the study areas, respectively, had CP contents of 9.92% and 8.19%. The value for CP content of grasses from highland agro-ecology was higher than that of midland areas. Such differences may be associated with the reduction in the proportion of legumes in the pasture with a decrease in altitude, and this is in line with the findings of Alemayehu (1985) and Mekuanint and Girma (2016). The CP values from natural grasses are closer to the minimum value reported by Milford and Minson (1966) and Van Soest (1982), required for optimum rumen microbial function; hence, they can support the maintenance requirements of ruminants with slight supplementation.

The crude protein contents, except barley straw, of the crop residues reported in the current study are extremely lower than the minimum level of CP 7% required for optimum rumen microbial function Milford and Minson.(1966) Van Soest,(1982). The CP value 8.51% obtained from enset leaf and leaf midribs was higher than the minimum CP value 7% required for optimum rumen microbial function Milford and Minson, (1966); Van Soest, (1982). The results of the current work agree with the report of Seyoum and Fekede (2008) that cereal crop residues are normally characterized by low digestibility and energy value, which are both inherent in their chemical composition. The CP contents of enset leaf and midribs obtained in the current study area are lower than the average CP value of 10.37% reported by Dirsha (2019) in Gurage Zone, Southern Ethiopia, and 13.15% reported by

(Mohammed *et al.*, 2013).

The in vitro dry matter digestibility (IVDMD) for maize Stover was 54.53%, which is lower than the value reported for maize Stover (58.65%) by (Chalchissa *et al.*, 2014). The value reported for wheat straw 52.23% in this work Table 8 was lower than that from all reported values for the straws of cereal crops in the current study and higher than the results 41.92% in Gassera and 42.22% in Ginnir districts in the Bale zone of the Oromiya region reported by Mekuanint and Girma (2017). The mean In Vitro Digestible Organic Matter in the dry matter (IVDOMD) for cereal crop residues ranged from 52.23% to 56.3% wheat straw and teff straw in the district. The results of the current study on IVDMD of crop residues were in line with the reports of Buxton and Russell (1988) and Seyoum and Fekede (2008), who reported that cereal crop residues are normally characterized by low digestibility and energy value, which are both inherent in their chemical composition. The IVDMD for maize Stover reported in the current study was 54.53%, which was lower than the reported value of 58.65% by Chalchissa *et al.* (2014).

The average energy contents of straws in this study were within the range reported by Solomon (2004) and Yitaye (1999), but the ME recorded in the current study is much higher than the ME content of 5.96 MJ/kg DM for wheat straw reported by Chalchissa *et al.* (2014). The energy content of native grass in the current study was (8.88 MJ/kg DM) in dega and (8.99 MJ/kg DM) in Weinadega agroecology, which is comparable with the reports of Zinash *et al.* (1995) (8.19 MJ/kg DM) and Yitaye (1999) (8.17 MJ/kg DM). The energy content of the maize stover in the study area (8.18 MJ/kg DM) was higher than the report of Yitaye (1999), which was 7.33 MJ/kg DM, but lower than that reported by (Chalchissa *et al.*, 2014) which was 8.79 MJ/kg DM. The observed variations in the value of the energy content of crop residue among agro-ecologies could probably be associated with differences in the agro-ecology, rainfall, environment, soil type, and the type of crop grown in each agro-ecology.

The neutral detergent fiber (NDF) content of the straws of cereal crops in the current study was between teff (75.25%) and barley (51.25%), lower than the value reported by Sisay (2006), which reported greater than 70% average NDF contents for cereal crop residues. Comparable results of 79.4 and 72.98% were reported for the straws of cereal crops,

respectively, by (Alemu *et al.*, 1989) and Solomon (2004). The NDF contents of 78.6, 81.5, and 82.13%, respectively, for wheat straw, teff straw, and maize Stover were reported by (Chalchissa *et al.*, 2014). Roughage feeds with an 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 (Singh and Oosting, 1992). The NDF content of barley straw identified in this study (Table 8) is found in the range of 45–65% and could be classified as medium-quality roughages that may not impose drawbacks on animal performance. The NDF content of leaf ensiled was 61.82% for High land agro-ecology, which was laid between the ranges of 45 and 65%, and it could be classified as medium-quality livestock feed Singh and Oosting, (1992). The NDF content of the maize Stover in the current study 77.35% is less than the NDF content of the maize Stover 82.13% reported by (Chalchissa *et al.*, 2014). The NDF content of native grass reported in this study 75.93% in High land and (76.64%) in Mid land was closer to the values reported by Ahmed (2006) and Solomon (2004). The higher NDF content could be a limiting factor on feed intake since voluntary feed intake and NDF content are negatively correlated (Ensminger *et al.*, 1990), and therefore, feeds with an NDF content greater than 65% in the current study could be classified as having low quality roughages, which could impose limitations on feed intake and animal production.

The ADF content of the maize Stover was 53.44%. Kellems and Church (1998) categorized roughages with less than 40% ADF as high quality and those above 40% as low quality. The results of the ADF content of feeds in the current study were higher than the ADF values reported by Yitaye (1999) for barley straw 39.45%, native grasses 29.98%, and maize Stover 44.22%. Variation in ADF content could be attributed to differences in temperature, crop management, and soil type. The ADF content of maize Stover 51.72% reported by (Chalchissa *et al.* 2014) was lower than the reported ADF value of 53.44% in the current study.

5.6. Estimated Annual Feed Balance

The annual available feed was compared with the annual requirements of the livestock population. The daily requirements of DM, DCP, and ME per TLU for maintenance were estimated based on the recommendations of Kears (1982) and McCarthy (1986) for TLU. The

overall estimated feed supply in the study area satisfies only 74.3%, 42.09%, and 76.37% of the maintenance requirements of DM, DCP, and ME in livestock, and it was 25.7%, 57.91, and 23.63 deficits per year, respectively, for DM, DCP, and ME (Table 10). Estimates on the amount of available feed supply and demand per year per agro-ecology were made, and there were differences in available feed demand and supply. In highland agro-ecology, the available feed supply met only about 68.9% DM, 44.83% DCP, and 69.49% ME of the maintenance requirement of livestock per farm per year. In mid land agro-ecology, on the other hand, the available feed supply satisfied about 79.7% DM, 39.36% DCP, and 83.25% ME of the maintenance requirements of livestock.

Within Highland agro-ecology, the available feed on a year-round basis in Amawute PA satisfied about 72.37% DM, 47.08% DCP, and 72.95 ME maintenance requirements, while in Eshegeda PA of Highland agro-ecology, livestock feed balance and the available feeds could only satisfy the maintenance requirements of 65.07% DM, 42.35% DCP, and 66% ME, respectively. On the other hand, in PAs of Dugeda, Adelesilasie, Soloke, and Anati found in Mid-land agro-ecology, the available feed can only satisfy the maintenance requirements of 83.37%, 81.25%, 77.99%, and 75.89% DM; 41.17%, 40.11%, 38.51%, and 37.47% DCP; and 87.08%, 84.82%, 81.46%, and 79.27% ME, respectively. It was indicated in Table 18 (contradictory with above) that the total estimated annual feed supply in the study area of Soddo a district in Gurage zone met only about 74.3% (DM), 42.09% (DCP), and 76.37% of the of the maintenance requirements of livestock.

The greater feed deficit encountered in the district might be associated with poor quality of roughages and the absence of supplements from different agro-industrial products. The observed negative feed balance in DM requirement in the current study agrees with the report of(Dawit *et al.*, 2013) from selected Kebeles of Adami Tullu Jiddo Kombolcha District of East Showa Zone in Oromiya region and (Selamawit *et al.* 2017) from north Achefer district in Amhara region. However, it disagrees with the report of Sisay (2006), who reported a surplus DM supply compared to the total annual livestock requirement in the North Gondar zone of Ethiopia.

6. CONCLUSION AND RECOMMENDATION

6.1. Conclusion

The study was conducted in the two agro ecologies of the district because the two areas are well known for its higher number of cattle population in the District. In the district no research has been conducted to gives information about major feed resources available at different agro ecologies of the study area of Livestock, so the study is justifiable to have recorded and realistic information for future development work. A total of 166 livestock owner respondents were Simple random selected and data were collected through a questionnaire and personal observation. The result of the study showed that the livestock production system in the district was a mixed crop-livestock production system. The overall family size per household of 6.72 ± 0.20 , the cattle population of 7.17 ± 0.3 heads (6.84TLU), and the land holding of 1.29 ± 0.325 hectares per household were obtained in this study. About 64.1% and 35.9% of households in the study areas indicated that the highland agro-ecology of the study areas, the major feed resources of cattle were crop residue, natural pasture, Enset leaf, and leaf midribs, while it was natural pasture, crop residue, and maize Stover in midland agro-ecology. Annual feed supply in the district satisfies 68.9%, 79.7% TDM, 44.83%, 39.36% TDCP, and 69.46%, 83.25% TME of the maintenance requirement of livestock in TLU per year in highland and midland agro-ecologies, respectively. Major Livestock constraints are shortage of feed, poor, high-cost feed, inadequate extension and training service, and shortage of manpower. It was concluded that, due to poor husbandry practices, the productive performance of livestock was low. Therefore, intervention in husbandry practices, mainly improvement of feed and breed, should be done to increase milk production and productivity. Cattles feed deficit was serious and needed strong intervention and attention.

6.2. Recommendation

Therefore, based on the above conclusions, the following recommendations are forward;-

- For more efficient utilization of crop residues, practical trainings that give understanding towards feed treatments and conservation should be introduced and practiced, and focus should be given on low-cost feed ration formulation.
- Provide extension and training services to alleviate the skill gap observed among farmers.

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APPEDICES

Appendix Table 1: Conversion factors of livestock number to tropical livestock unit (TLU)

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

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

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

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

Donkeys

2.5

192.5

14.9

Source: Kears (1982) and McCarthy (1986)



Figure 2 Inter view



Figure 3 Interview



Figure 4 Teff straw conservation methods in soddo district



Figure 5 Maize straw conservation methods in soddo district



Figure 6 feed conservation methods in midland area of soddo district



Figure 7 Water source in mid land in Soddo District East Gurage zone

Appendices 3. (QUESTIONNAIRE) Section

A. Instruction to the Enumerator

Questionnaire given to livestock owner to study Assesment Of Major Livestock Feed Resources and Its Nutritional Value In Soddo District, East Gurage Zone, Central Ethiopia

B. General Information

1. Name of interviewee _____ Sex ___ age ____
2. Marital status of the household 1 = Single 2= Married 3= divorced
3. Educational level 2.1 Illiterate 2.2 Read &write 2.3 Primary school 2.4 Junior school
2.5 High school 2.6 Above high school
4. Family size 4.1 Male ----- 4.2 Female ----- 4.3 Total-----

5. Total Number of Household member by age group

Age group	Male	Female	Total
<5			
5-10			
11-20			
21-40			
41-60			
>60			

6. Land holding (farm size in hectare).1
1 Crops land

2 Grazing land

3 Forest

4 Fallow land

5 Homestead

6 Total size

7. What was the trend of land holding for the last ten years?

1= increasing

2= No change

3= Decreasing

8. If you say decreasing what is the reason?-----

9. Land utilized for major types of crops

a. Wheat-----ha.

b. Barley-----ha.

c. Tef -----ha

d. Maize-----ha

e. Sorghum-----ha

f. bean-----ha

85

g. Field Pea -----ha

h. Chick pea -----ha

S/N	Livestock Type		Breed type		Total	Importance
			Local	Cross		
1	Lactating cows					
2	Dry cow					
3	Heifer					
4	Oxen					
5	Bulls					
6	Calf	Male				
		Female				
7	Sheep					
8	Goat					
9	Equines	Horse				
		Mule				
		Donkey				
10	Poultry					

10. Grain yield obtained from major crops

a. Wheat-----Quintal.

b. Barley-----Quintal.

- c. Teff -----Quintal
- d. Maize ----- Quintal
- e. Sorghum ----- Quintal
- f. bean-----Quintal
- g. Field Pea -----Quintal
- h. Chick pea ----- Quintal

- 8. Number of Livestock & importance by type,
- 9. What is the trend of herd size in the last ten years (increased or decreased?)
- 10. If you say increase or decrease Specify the reason for the change in the trend -----

- 11. Specify the composition of your cattle herd

S/	Type of cattle	Local breed	Crossbred	Total
1	Cow			
2	Heifers			
3	Bulls			
4	Oxen			
5	Calves			
	Total			

12. What is your major farming activity? 1 = Livestock production

2 = Crop production

3 Mixed

crop-livestock production

- 12. Purpose of keeping dairy cattle: - 1 Milk sale 2 Milk consumption 3 asset 4 others:-
- 13. Who is responsible for following dairy cattle management activities?
- 13.1. Herding: - 1. Head 2. Spouse 3. Children 4. Workers

- 13.2. Fodder harvesting: - 1. Head 2. Spouse 3. Children 4. Hired
- 13.3. Feeding: 1. Head 2. Spouse 3. Children 4. Hired
- 13.4. Milking: 1. Head 2. Spouse 3. Children 4. Hired
- 13.5. Transport of milk and milk products to market:- 1. Head 2. Spouse 3. Children
4. Hired
- 13.6. Processing of milk: 1. Head 2. Spouse 3. Children 4. Hired

Section D. Feeding management of animals

1. What are the major feed resources available for Livestock in your area?

- 1) Natural pasture 2) Crop residue 3) Industrial by product 4) Hay

Do you have any experience of delivery of measured amount of feed dry matter to your cows?

1. Yes 2. No

1. If yes, How much kg of dry matter do you feed your cows of crossbred per day _____ local

2. Does feeding differ during early, mid and late lactation period? 1) Yes 2) No. 5, 1

6. Do you have market opportunity for concentrate feed purchase for your animal? 1. Yes 2. No

7. If yes, who are the suppliers? 1. Bureau of Agriculture 2. Traders 3. Cooperative 4. NGOs

8. Is there forage development practice in your area? 1. Yes 2. No

9. If yes, who provides extension service? 1. Government 2. Cooperatives 3. NGO

10. Who provides a technical and other supports regarding to improved forage development?

1. Government 2. Cooperatives (Union) 4. NGO

11. Have you any experience in practicing forage conservation? 1. Yes

2. No 12, If yes, in what type of forage conservation do you have experienced?

1. Hay making 2. Silage making 3. By feed processing 13,.

What is the estimated Kg/lit of concentrate feed purchased annually?

- 1) Wheat bran _____ 2) Balanced ration (concentrate) ----- 3) Molasses _____

Hay _____ 5) straw _____

11. What type of feeding system do you apply in feeding of your dairy animals?

- 1) Individual feeding system 2) Group feeding system 3) Randomly
feeding system 4) Other specify please: _____