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

BY

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Ambo University

ASSESSMENT OF FEED RESOURCES AND DETERMINATION OF MINERAL STATUS OF LIVESTOCK FEED IN META ROBI DISTRICT, WEST SHEWA ZONE, OROMIA REGIONAL STATE, ETHIOPIA

A Thesis Submitted to School of Graduate Studies, College of Agriculture And Veterinary Sciences, Department of Animal Sciences: In Partial Fulfillment of the Requirements for the Degree of MASTER OF SCIENCE IN ANIMAL PRODUCTION

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As Thesis research advisors, we hereby certify that we have read and evaluated this Thesis, prepared under our guidance, by Endale Yadessa, entitled ''**Assessment of Feed Resources and Determination of Mineral Status of Livestock Feed in Meta Robi District, West Shewa Zone, Oromia Regional State, Ethiopia**'' and recommend that it be submitted as fulfilling the Thesis requirement for the degree of Master of Science in Animal Production.

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DEDICATION

This thesis is dedicated to my beloved mother W/ro Beletech Arbi who passed away when I joined Addis Ababa university for my BSc. Her love, proper guidance and support since my childhood contributed a lot in my career and day to day life.

STATEMENT OF THE AUTHOR

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

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ACRONYMS AND ABBREVIATIONS

AI	Artificial Insemination
AOAC	Association Of Analytical Chemists
Ca	Calcium
CL	Critical Level
Cm	Centimeter
CP	Crude Protein
CRV	Central Rift Valley
CSA	Central Statistic Authority
Cu	Copper
^{0}C	Degree centigrade
DM	Dry Matter
DTPA	Diethylene Triamine Pentaacetic Acid
FAO	Food and Agricultural Organization
Fe	Iron
g	gram
GDP	Growth Domestic Product
ha	Hectare
HH	Household
ILCA	International Livestock Center for Africa
ILRI	International Livestock Research Institute
K	Potassium
Kg	Kilo gram
LIVES	Livestock and Irrigation Value Chains for Ethiopian Smallholders
LSD	Least Significant Difference
LU	Livestock Unit
M^2	Meter square
masl	Meter Above Sea Level
Meq	Mill equivalent
Mg	Magnesium

mg	milligram
mm	Millimeter
Mn	Manganese
Na	Sodium
NGO’s	Non-Governmental Organization’s
NRC	Nutrient Requirement for dairy cattle
P	Phosphorus
PA	Peasant Association
Ppm	Part Per Million
S	Sulfur
SAS	Statistical Analysis System
SE	Standard Error
SPSS	Statistical Package for Social Science
T	Tone
TLU	Tropical Livestock unit
Zn	Zinc

BIOGRAPHICAL SKETCH

The researcher was born in 1979 at Ambo district, West Shewa Zone, Oromia Regional state, Ethiopia. He attended his elementary and secondary school at Ambo Addis Ketema and Ambo senior secondary school, respectively. He earned his honored diploma in general agriculture from the then Ambo College of Agriculture in 2000.Then, he served for 4 years at Jeldu District Agricultural Office as Junior Expert. His initial exposure to scientific research was in 2005 when he joined Holeta Agricultural Research Center as Technical Assistant. He pursued his first degree at Addis Ababa University and graduated in BSc. Degree in Applied Biology in 2008. Following receipt of his BSc, he worked as production supervisor at Assela Malt Factory for a couple of years but realized that a research career was really what he would be most happy with. Eventually, he rejoined his area of keen research interest in 2010 as livestock researcher at Tepi Agricultural Research Center. To quench his thirst for professional and personal development, he joined again his initial institution in 2013 where he began his academic journey. His general research interests are in the area of Animal Production especially Animal Feeds and Nutrition.

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ABSTRACT

The study was carried out in Meta Robi district, West Shewa Zone, Oromia Regional State to identify the types and sources of feeds, constraints in feed production, transportation, utilization and supply, estimate annual feed produced, maintenance requirement, annual feed balance and determine the mineral status of natural pasture and soil samples. Secondary data sources and field observations, key informants discussions and semi-structured questionnaire interview were employed to generate data. The district was stratified into upper, mid and lower altitudes and a total of 90 respondents (upper=30, mid=30 and lower=30) were randomly selected and interviewed individually. Samples of feed and soil were collected from three altitudes during the dry and wet seasons and their mineral concentrations were determined. The results of the study indicated that the major feed resources were grazing of natural pasture (58.9%), wheat straw (42.4%), barley straw (30%) and hay (21.1%). During the dry season, 90% of the respondents feed their animal crop residues, hay (58.8%) and stubble grazing (56.1%). Natural pasture was the major feed source during the wet season. Most respondents (46.7%) had their own natural pasture lands, 86.7% produced crop residues from their crop land whereas only 25.6% were producing improved forages. The major constraints related to livestock feed were shortage of grazing land, absence of feed processors and retailers, shortage of technologies in feed production and lack of awareness of the respondents. The total maintenance DM of feed requirement of the animals per year in the district was 388,859.8 tons while the actual DM of feed production was 212,047.15 tons. The total DM of feed produced per year fulfilled the maintenance requirement of the animals only for 6.54 months of the year. Concentrations of most minerals in the soil were above the critical level of plant growth and most macro minerals in the feed were below the requirement of dairy animals while micro minerals were above the requirement of dairy animals except Mn. Alternative feed production technologies such as development of improved forages, efficient feed utilization technologies (eg. provision of chopper) and natural pasture land improvement measures should be taken. To compensate the mineral deficiency of natural pasture, improved forages with better yield and mineral contents should be provided for livestock. Provision of common salt and/or locally available natural soil as mineral source should be encouraged.

***Key words: Assessment, Feed resources, Macro minerals, Micro minerals, Meta-Robi*.**

1 INTRODUCTION

Livestock production is an integral part of the farming systems in Ethiopia and plays a vital role in the livelihood of the majority of the people (Yeshitila *et al.*, 2008). In Ethiopia, livestock generates more than 85% of the farm cash income. In terms of contribution to the national economy, livestock contribute about 13–16% of total Growth Domestic Product (GDP) and the share to total exports is about 16% (Yayneshet, 2010). In spite of this, the productivity of livestock is low mainly due to poor genetic makeup of local animals, poor nutrition and poor veterinary care among which poor nutrition is the major limiting factor (Yeshitila *et al.*, 2008).

The major livestock feed resources in the highland of Ethiopia are natural pasture and crop residues where all ruminants as well as equines depend on them. The use of agro-industrial by products such as oil seed cakes, milling by products, molasses and improved forages is restricted to the emerging private dairy and fattening farms (Yayneshet, 2010).

The availability of feed resources and the nutritional quality of the available feeds are the most important factors that determine the productivity of livestock. One of the major problems to low milk production in the country is associated with shortage of livestock feeds both in quantity and quality, especially during the dry season (Zewdie, 2010).The role of natural pasture grazing as a major livestock feed resource is diminishing from time to time due to shrinking grazing land size (Yayneshet, 2010). The use of native hay is limited in coverage and it is better in terms of its feeding value than crop residues if timely cut, proper handling and storage measures are applied. 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).

A basic shortcoming of the natural grasslands as a source of feed for ruminant livestock is their low production of dry matter due to a combination of the negative effects of inadequate rainfall and soil nutrients. The seasonality of plant growth, which is a reflection of the annual rainfall distribution pattern, further restricts the availability of herbage for the grazing animal to four or five months of the wet season over most of the natural grasslands and the low quality of the herbage is another shortcoming of natural grassland (Ulfina *et al.*, 2013).

As a result of increasing crop production, currently crop residues represent the largest amount of livestock feed and it provide 10 to 15% of the national intake of feed by livestock and in some areas the estimate is up to 50% (Alemayehu, 2003). In selected wheat based crop-livestock production systems of the Ethiopian highlands, the contribution of crop residues and aftermath grazing account for 70% of the total feed supply, while native pasture accounts for only 30% of the total feed supply (Seyoum *et al*., 2001).

On the other hand, inadequate mineral intake through feed leads to reduced production and productivity of the animals. For example, reproductive disorders associated with copper deficiency in grazing ruminants include: low fertility associated with delayed or depressed oestrus, and long post-partum return to oestrus period; infertility associated with anoestrus and abortion (Corah and Ives, 1991). According to this study, an inverse relationship between serum copper levels and important reproductive parameters such as days to first service (56 vs. 70 days), services per conception (1.1 vs. 4.4) and days to conception (56 vs. 183) in dairy cows with high and low serum copper levels, respectively were observed (Corah and Ives, 1991).

Five percent of the body weight of an animal consists of minerals and at least 15 mineral elements have been identified as nutritionally essential for ruminants. These are seven major or macro minerals and eight trace or micro minerals (NRC, 2001). The macro minerals are important structural components of the bones and other tissues and serve as important constituents of body fluids. The trace minerals are present in body tissues in very low concentrations and often serve as components of metalloenzymes and enzyme cofactors or as components of hormones of the endocrine system (Engle, 2001).

The mineral status in cattle depend upon the daily mineral intake through feed, apart from non nutritional factors such as season, age, weight, pregnancy and lactation stage (Khan, 1995). But, the mineral composition of forages vary according to different factors such as plant age, soil, fertilization practice, species, variety, seasons and grazing pressure (Aregheore, 2002). The other important factor that determines the mineral contents of feed is storage method on the macro mineral contents of hay (Fekede, 2013).The adequacy of the diet in essential minerals can be determined by chemical analysis of animal body tissue, fluids and forages which are being eaten by the animals (Shakira *et al.*, 2011).

Minerals that are mostly deficient in the diet of livestock in most of the regions of the world include, calcium (Ca), Phosphorus (P), Magnesium (Mg), Sodium (Na), Sulfur (S) and the trace elements Cobalt (Co), Cupper (Cu), Iodine (I), Manganese (Mn), Selenium (Se), and Zinc (Zn) (Goswami *et al.*, 2005).

Information on the mineral content of feeds of the central and western parts of Ethiopia as influenced by season and altitude are scanty (Aschalew *et al.*, 2006). In addition, the mineral content of grazing pasture is influenced by botanical composition of pastures (Jumba *et al.*, 1995) and season of the year (McDowell, 1997). When dietary concentrations of the feeds are unknown or highly variable due to availability, season, location, forage species and animal potentials, it is important to determine mineral concentrations in animals region-wise, to estimate needs of livestock so as to obtain optimum productivity (Sharma *et al.*, 2003a). For grazing ruminant livestock, which obtain all or most of the nutrients required from pastures and crop residues, knowledge of the mineral content of such feeds is essential.

According to Zewdie (2010), assessment of the quantity and quality of available feed resources in relation to livestock requirement has not been yet well addressed in most livestock production areas of the country. In highlands of Ethiopia, 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 (Funte *et al.*, 2010). In addition to the above factors, the other major constraints for livestock production include costs of feeds and its marketing systems (Sintayehu *et al.*, 2008). According to Mesfin *et al.* (2014) among the dominant factors contributing to the feed shortage both in terms of quantity and quality is the poor feed marketing system characterized by poor market information, localized markets and limited premium price for quality. Incentives through profitable market outlets can facilitate technical efficiency of feed production, which could include better agronomic practices, improved genetic resources, and better use and conservation methods. Improving market efficiency will increase demand and margins to producers and other market actors. Hence, feed market development can be considered as an important factor in alleviating the feed shortage problem (Berhanu *et al.,* 2009).

To obtain improvement in animal production and productivity, an assessment should be done on the types and sources of livestock feed resources, total DM feed production of the area, livestock feed requirement and mineral nutrition, whether the animal is in a free ranging system or under confinement. Therefore, this study was designed with the following specific objectives:-

- To identify the types and sources of livestock feed in the district.
- To identify the major constraints in livestock feed production, transportation utilization and supply
- To estimate annual feed produced, total maintenance requirement of the animals and annual feed balance and
- To determine the macro and micro minerals status of natural pasture and soil samples in different altitudes and seasons.

2. LITERATURE REVIEW

2.1. Land holding size and land use systems in the highlands of Ethiopia

Average land holding varies considerably in the highlands reflecting differences in population density. The land size allotted to individual farmers by a Peasant Association (PA) as per the land reform declaration of 1975, depended on family size, fertility of the land, the number of peasant association (PA) members and the total land area available within the PA (Getachew *et al*., 1993). Agaje *et al.* (2001) reported that the average farm size per household in west and north Shewa zones was about 4.1 and 3.3 hectares, respectively. The present practice to a newly married son is literally sharing a piece of land from his parents' share. Most farms in Ethiopia are fragmented and smallholder mixed crop-livestock systems (Zewdie, 2010) and farmers practiced a cereal dominated cropping system in the highland areas of the country (Belay *et al.*, 2012). Yeshitila (2008) reported that land and livestock holdings showed a direct linear relationship, where farmers with large land holdings have higher livestock holdings and when land holdings became smaller there is a trend of keeping more numbers of small ruminants than cattle. Belay *et al*. (2012) reported that the overall average landholding per household in Dandi district was 2.5 ha and major proportion (63.2 %) of the land owned per household was used for crop production and hay and pastureland occupied 17.6% of the total land owned.

2.2. Livestock holding Size and herd structure

The number of livestock owned varies from location to location depending on several factors, like feed availability, disease condition and resource status of the farmers. In mixed farming system of the highlands and mid-altitudes of Ethiopia where crop production is important; cattle are the most important livestock species for cultivation, threshing and manure production (Getachew *et al*., 1993). According to Agajie *et al.* (2001) about 98% of the respondents in west and north Shewa zone owned a total herd size of about 9.0 livestock units ranging from 0.2 - 46.3 and 5.4 ranging from 0.2- 19.4, respectively. In Jelldu district, livestock holding especially cattle, sheep, goats, donkey, horses and poultry was in the order of 5.35, 0.49, 0.03, 0.22, 1.32 and 0.02 (Bedasa, 2012). Households with larger landholdings keep more animals because they need more draught power to cultivate their land, and this also enables them to produce more straw that helps to support a greater number of animals (Bayush *et al.*, 2008). In mixed production systems where animals are used for draught and transport, the proportion of mature oxen or donkeys in the herds tends to be relatively high (ILCA, 1990).

2.3. Dynamism in livestock production

About 73% of the sample farmers in west and north shewa zones indicated that the livestock population has decreased in the past two decades (Agajie *et al.*, 2001). As this author investigated the major factors responsible for the declining of livestock population were feed shortage and diseases. A non-equilibrium event (variable climate) is probably a core environmental variable in regulating cattle herd dynamics in southern Ethiopia (Ayana, 2011). Kelemework (2001) also reported that the average livestock holding was declining over a period of two decades (1977-1997). According to this report the average cattle holding of the household declined from 38 to 13, sheep 37 to 17 and goats 125 to 53. Contrary to this, Samson and Frehiwot (2014) reported that from 1995/96 to 2012/13 the cattle and shoat population grew from 54.5 million to over 103.5 million with average annual increment of 3.4 million. On the same report, in 2024/25 the cattle, sheep and goat population in sedentary areas of Ethiopia are estimated to reach 75, 42.8 and 39.6 million heads, respectively.

2.4.Crop-livestock integration

Crop and livestock production systems are an integral part of one another (Kallah and Adamu, 1988). Crop residues provide fodder for livestock while, occasionally, grain provides supplementary feed for productive animals (Al Hassan *et al.*, 1983). Animals improve soil fertility through manure and urine deposition and animal power for farm operations and transport. Sale of animals sometimes provides cash for farm labor and agricultural inputs (Vinod *et al*., 2012).

2.5. Animal feeding practices 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).The feeding systems in the country include communal or private natural grazing and browsing, cut and carry feeding, hay and crop residues. At present, in the country stock are fed almost entirely on natural pasture and crop residues. Grazing is on permanent grazing areas, fallow land and cropland after harvest (Tesfaye, 2008). Adane and Berhan (2005) reported that the herbage yield and nutritional quality of natural pasture is generally low. In certain areas where improved forage crops have been introduced, farmers failed to utilize them at its optimum developmental stages, which would ensure an appropriate balance between quality and quantity to satisfy livestock requirements and support reasonable animal production (Taye, 2004). In the mixed crop-livestock systems of the Ethiopian highlands, the total feed resources available for livestock production come from permanent pastures and transient pastures between cropping cycles, crop residues and crop aftermath grazing. Forage obtained from crop thinning and defoliation from annual crops and perennial crops is important for livestock feeding (Fekadu, 1996). However, these feed resources are high in fiber, with low to moderate digestibility and low levels of nitrogen (Tsige, 2000). Such low quality feeds are associated with a low voluntary intake, thus resulting in insufficient nutrient supply, low productivity and even weight loss (Hindrichsen *et al.*, 2004). Without providing common salt, animals in most parts of the country do not get mineral mix in their basal diet. Supplementation with multi-nutrient blocks and local mineral soils in some parts of Ethiopia may provide an adequate or even excess amount of most of the essential minerals except phosphorus (Tolera and Seid, 1994).

2.6. Water sources and frequency of watering

According to Shitahun (2009) the three types of water sources identified in Bure district were river (58%), spring (32%), and hand dug well (10%).Yeshitila (2008) also reported that the water sources in Alaba district was river and ponds. The surveyed households claim shortages of water and farness of water sources from their vicinity. Problems of water shortages are highly dictated by seasonality where it becomes more pronounced during dry period. During this period, farmers will be obliged to travel distances of a day and normally watering frequency decreases. Zewdie (2010) reported that water shortage is the major constraint during the dry season for peasant associations (PAs) situated far away from Lake Ziway and main rivers. Based on personal observation, herders in CRV traveled long distances with their cattle for 9 to 12 hours in every other day to reach to the watering points. On the other hand about 99% of the respondents around Ginchi area indicated that there was no shortage of water for both domestic and livestock watering and during the dry and small rainy seasons, water is available from permanent water sources particularly rivers (93.5%) and streams (6.5%) which are sufficient in quantity to support the livestock in the area. The watering frequency was positively correlated with number of cattle owned. The interval was larger for large herd size because farmers could not water their animals by fetching water from the ponds as it requires large amount of labor (Funte *et al*. 2010).

2.7. Feed availability and sources in Ethiopia

Inadequate feed supply, both in terms of quantity and quality, is the major constraint affecting livestock production in Ethiopia. Feed scarcity is indicated as a factor responsible for the lower reproductive and growth performance of animals especially during the dry season (Legesse, 2008). The dry season is characterized by inadequacy of grazing resources as a result of which animals are not able to meet even their maintenance requirements and lose substantial amount of their weight. Animal feeds were classified as natural pasture, crop residue, improved pasture and forage and agro industrial by-products of which the first two contribute the largest share in livestock production (Alemayehu, 2003; Tolera *et al.*, 2012). The use of communal grazing lands, private pastures and forest areas as feed resources have declined while the use of crop residues and purchased feed have generally increased (Benin *et al.*, 2003). 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 fibrous agricultural residues contributes a major parts of livestock feed especially in the populated countries where land is prioritized for crop cultivation.

2.7.1. Natural pasture

In most areas of sub-Saharan Africa, the major even the sole feed source available for large parts of the year in smallholder production systems are natural pastures (Gylswyk, 1995). 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). The total area of grazing and browsing in the country is 62,280 million hectares out of this, 12% is in the farming areas and the rest is around the pastoral areas (Alemayehu, 1985). Alemayehu (1998a) estimated that 80-85% of the livestock feed in Ethiopia comes from natural pasture. 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, low in nitrogen, very low protein and energy content (Topps, 1995; Assefu, 2012). The yield as well as quality of pasture is very low due to poor management and over stocking (Ashagre, 2008). In general, grazing land productivity is declining at a higher rate because of temperature stress and scarcity of rainfall, which is favored by deforestation that denies humid environment to the area. In addition to this, the transfers of grazing lands to cultivation for cropping and poor grazing land management are some of the reasons for dry matter reductions from grazing lands (Yeshitila *et al.*, 2008). Natural pastures would be adequate for live weight maintenance and weight gain during wet seasons, but would not support maintenance for the rest of the year (Zinash *et al.*, 1995). Natural pastures in the highlands of Ethiopia are rich in species composition, particularly indigenous grasses and legumes (Assefu, 2012). Among grass species commonly growing belongs to the genera *Andropogon*, *Digitaria*, *Panicum*, *Pennisetum* and *Trifolium* (Yihalem *et al.*, 2006). Moreover, most of this native pastures are generally confined to degraded, shallow upland soils, fallow cropland and to soil that cannot be successfully cropped because of physical constraints such as flooding and water logging (Assefu, 2012).

2.7.2. Grass hay

Hay is forage harvested during the growing period and preserved by drying (Assefu, 2012). The aim of hay making is to reduce the moisture contents of green crops to 15-20% to inhibit the action of plant and microbial enzymes (Banerjee, 1998). Hay in central highland of

Ethiopia is usually harvested after the crude protein (CP) of the pasture passed peak production and 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). This level of CP content reduces feed intake and affects digestibility (Kidane, 1993). According to FAO (1997), annual and perennial grass from natural pasture consumed during the dry season and often at late stage of maturity together with the straw and stalk from cereal crops constitutes low quality forages, with high lignified cell wall and poor nitrogen. The quality of hay prepared varies with grass legume proportion, leaf to stem ratio and physiological development of the forage up on harvest (Assefu, 2012). Mature grass, especially those that are weather leached or bleached are low in digestible energy and protein, as well as in soluble carbohydrate, carotene and some of the minerals (Ensminger *et al.*, 1990).

2.7.3. Crop residues

Crop residues are the fibrous by-products which result from the cultivation of cereals, pulses, oil plants, roots and tubers and represent an important feed resource (Yayneshet, 2010).They are important in fulfilling feed gaps during periods of acute shortage of other feed resources. A report by Tolera *et al.* (2012) indicated that crop residues contribute to about 50% of the total feed supplied in Ethiopia. The amount of crop residue produced is closely related to grain production, farming system, the type of crops produced and intensity of cultivation. About 12 million tones of crop residues were produced annually from 6 million hectare of farmland in Ethiopia (Daniel, 1988). A report by CSA (2008) indicted that crop residues production was increased to 31.52 million tones. Zinash and Seyoum (1989) reported that 63, 20, 10, and 7% of cereal straws are used for feed, fuel, construction, and bedding purposes, respectively. Farmers in the Ethiopian highlands have a tradition of conserving crop residues from *teff* (*Eragrostis teff*), barley, wheat and sorghum (Reed and Goe, 1989). Straws from *teff*, barley and wheat form the largest component of livestock diet in the mid and highland areas, while maize, sorghum and millet stover's constitute larger proportion of livestock feed in lower to medium altitudes (Alemayehu, 1985).

2.7.4. Improved forage and pasture crops

A large number of annual and perennial forage and fodder species have been tested in the mid altitude under rain fed conditions in Ethiopia. As a result, many improved herbage species have been identified for the ecology. *Chloris gayana, Panicum coloratum, Panicum maximum, Melinis minutiflora, Pennisetum purpureum, Zea mays, Sorghum vulgare, Sorghum alumum*, *Desmodium uncinatum*, *Staylosanthes guanensis*, *Leucanea leucocephala, Dolichos lablab, (Lablab purpureus), Macroptilum atroparpurem* and *Vicia atropurpurea* are the most promising pasture and fodder species and are recommended for mid altitude (Lulseged and Alemu, 1985). Improved forages mainly legumes, can improve the productivity of natural pastures by improving the fertility status of the soil. They can also improve the feed value of the native pastures since they have more protein content than naturally occurring grasses (Yeshitila *et al.,* 2008).

2.7.5. Agro-industrial by-products

The major feed resources in the country are crop residues and natural pasture, with agro industrial by-products and manufactured feed contributing much less (Berhanu *et al.*, 2009). 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 flour milling industries (wheat bran, wheat short, wheat middling and rice bran), edible oil extracting plants (noug cake, cottonseed cake, peanut cake, linseed cake, sesame cake, sunflower cake etc), breweries and sugar factories (Molasses). The current trends of increasing urban population has a significant effect on the establishment of agro-industries due to the corresponding increasing demand for the edible main products (Yayneshet, 2010).

2.7.6. 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*, *tela*, *chat* left over called *geraba*, fruits and vegetables reject.

2.8.Total annual feed balance and maintenance requirement of livestock

According to Funte *et al.* (2010), the annual DM production of feed could satisfy only two third of the total DM requirements of the livestock in southern Ethiopia. But some of the DM requirements might be compensated via the supplementation of weeds and sugarcane tops. The same source also indicated that 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 Belesa district of Amhara region, the existing feed supply on a year round basis satisfies only 72.7 % of the maintenance DM requirement of livestock and this deficit of feed supply could also coupled with low quality of crop residue, over matured and improperly conserved natural pasture and browse leaves (Tessema *et al.,* 2003). Bedasa (2012) also indicated that the dry matter production was below annual livestock requirements in the highlands of the Blue Nile basin. Contrary to these results, Shitahun (2009) reported that the existing feed supply on a year round basis accounted for about 104.79% of the maintenance DM requirement of livestock per household in Bure district.

2.9. Livestock production constraints in Ethiopia

A study conducted by Dawit *et al.* (2013) indicated that feed shortage is the major constraint identified by most of the respondents in Adami Tullu Jiddo Kombolcha District. Recurrent drought, prolonged dry period and uneven distribution of rainfall which affects crop production and re-growth potential of grasses were also the factors which cause feed shortage in Adami Tullu Jiddo Kombolcha District. As most of the water bodies are recharged annually during the rains, erratic rainfall is hampering their proper recharge thereby affecting the livestock in the region as poor quality and inadequate quantity of water is affecting both livestock health and production. According to Belay *et al.* (2012) the major constraints limiting livestock production in Dandi district were feed shortage, animal health, labour scarcity and lack of capital. Similarly in North and West Shoa zones of Ethiopia, the most important livestock production constraints prioritized by the sample farmers were feed shortage, animal disease, inadequate veterinary services, shortage of cash, and shortage of water supplies (Agajie *et al.*, 2001). The interaction of these constraints affects the performance of the genetic potential of animals leading to subsistence level of livestock production.

2.10. Gender division of labor in livestock activities

Gender refers to the socially constructed roles and status of women and men, girls and boys. Gender roles, status and relations vary according to places (countries, regions and villages), groups (class, ethnic, religious), generations and stages of the life cycle of individuals (Shafaq *et al.,* 2010). Livestock management is a gender activity as both men and women are involved in it. Women are responsible for 60 to 80% of the feeding and milking of cattle in other parts of the world (Ali, 2007). Most farmers in Adaa Liben district indicated that females within age groups of 15-64 years were responsible for milking. Livestock herding and watering are the responsibility of male members of the family. Barn cleaning is the responsibility of female member of the family. Feed collection and live animal marketing were a routine work of males (Samuel *et al.,* 2008). Zewdie (2010) reported that milking was always done by females in CRV (around Ziway) and in Debre Birhan. Cattle herding was undertaken by males in both Debre Birhan and Ziway areas. Barn cleaning was largely done by females in Debre Birhan, while in Jimma and Sebeta it was mainly a task of males. In Dandi district, central Ethiopia 76% of children was involved in herding and watering of livestock. In the same district about 89.8, 95.9% and 94.7% household wife were involved in water collection, milking and barn cleaning, respectively. Milk processing and marketing was done by household wife. About 71.4% men are responsible for supplementing hay and crop residues to animals.

2.11. Mineral requirements of livestock

Approximately five percent of the body weight of an animal consists of minerals. At least 15 mineral elements have been identified as nutritionally essential for ruminants. These are seven major minerals - calcium (Ca), phosphorus (p), potassium (K), sodium (Na), chlorine (Cl), magnesium (Mg) and sulfur (S) and eight micro minerals - cobalt (Co), copper (Cu), iodine (I), iron (Fe), manganese (Mn), molybdenum (Mo), selenium (Se) and zinc (Zn) (NRC, 2001).

The macro minerals are important structural components of bone and other tissues and serve as important constituents of body fluids. The trace minerals are present in body tissues in very low concentrations and often serve as components of metallo enzymes and enzyme cofactors or as components of hormones of the endocrine system. Production, age, level and chemical form of elements in the feed ingredients, interrelationships with other nutrients, supplemental mineral intake, breed and animal adaptation can determine mineral requirements of the animals but there is greater degree of uncertainty in the mineral requirements of animals depending on such factors (Engle *et al*., 2001).

2.12. Natural sources of minerals for grazing livestock

2.12.1. Forages

Livestock normally obtain most of their minerals from the feeds and forages that they consume and their mineral intakes are influenced by the factors that determine the mineral content of plants and their seeds. The concentrations of all minerals in plants depend largely on four factors: plant genotype, soil environment, stage of maturity and climate. The importance of a given factor varies between minerals and is influenced by interactions with the other listed factors and with aspects of crop or pasture husbandry, including the use of fertilizers, soil amendments, irrigation, crop rotation, intercropping and high yielding cultivars (Neville, 2010).

Table 1: Recommended minimum element concentrations in pasture dry matter for livestock

Macro minerals(g/kg)	Cattle	Sheep
Calcium	3.5	3.0
Sodium	1.5	1.0
Chlorine	2.0	1.0
Potassium	5.0	4.5
Sulfur	1.5	2.0
Magnesium	1.5	1.0
Trace elements(mg/kg)		
Iron	40	40
Zinc	25	20
Manganese	25	25
Copper	5 to 12	5
Cobalt	0.10	0.10
Iodine	0.50	0.50
Molybdenum	0.10	0.10
Selenium	0.05	0.05

Source: Grace (1983)

2.12.2. Water and soil

Water is not normally a major source of minerals. Although highly variable, all essential mineral elements occur to some extent in water. Animals sometimes consume appreciable amounts of soil but this is also highly variable in its mineral contents (McDowell, 1983). Understanding spatial changes in soil nutrients is important, as they may differ markedly among identical locations subjected to natural and man-made disturbances. Land use patterns and vegetation play important role in soil nutrient transformations and fertility.

Table 2: Macro mineral compositions (ppm) of soils collected from different sites

Sites	Ca	P	Mg	K	Na
Jair	39.42	2.06	16.20	5.07	191.00
Hermokale	52.20	8.00	6.91	5.26	179.00
Arabi	67.86	6.30	8.42	6.31	60.32
Bole	4.10	2.54	0.98	3.35	84.73

Source: Sisay *et al.* (2007)

Table 3: Micro mineral composition (ppm) of soils collected from different sites

Sites	Fe	Cu	Mn	Zn
Jair	2.42	2.22	2.36	0.36
Hermokale	1.78	1.50	4.58	0.64
Arabi	0.78	0.66	2.96	0.50
Bole	1.00	0.28	0.90	0.50

Source: Sisay *et al.* (2007)

2.13. Major mineral elements required for plant growth

There are 14 mineral elements defined as essential for plant growth and reproductive success (Marschner, 1995). These are N, S, P, K, Ca, Mg, Cl, Fe, Zn, Mn, Cu, B, Mo, and Ni. Because of their essentiality, all plant contain some level of each of these elements and it should come as no surprise that plants have developed various forms of molecular machinery (i.e., membrane transporters) to acquire these mineral nutrients from their soil environment (Kochian, 1991).

2.14. Factors affecting mineral content of feeds and soil

Concentrations of mineral elements in forage are dependent upon the interaction of a number of factors, including soil, plant species, stage of maturity, yield, pasture management and climate (Reid and Horvath, 1980). Most naturally occurring mineral deficiencies in herbivores are associated with specific regions and are directly related to soil characteristics. There is a marked leaching of minerals and weathering of soils in tropical regions under conditions of heavy rainfall and high temperature, making them deficient in plant. Poor drainage conditions often increase extractable trace elements (i.e. Mn and Co), thereby resulting in a corresponding increase in plant uptake. As the soil pH increases, the availability and uptake of forage Fe, Mn, Zn, Cu and Co decrease, whereas Mo and Se concentrations increase (NRC, 2001).

2.14.1. Influence of Season on mineral concentration of feeds

The concentration of most mineral elements in grasses tends to change with season, with wet season herbage having relatively higher concentration of mineral elements (Lemma *et al.*, 2004). In Western Sudan, forages were adequate in copper during the wet season and deficient during dry season (Abdelrahman *et al*., 1998).The results of such studies indicated that season of production has impact on the contents of minerals in the pasture.

Table 4: Mean mineral concentration of grass herbage by season

Variable (DM bases)	Wet season	Dry season
Ca (%)	0.49± 0.03	0.61±0.05
P (%)	0.11±0.01	0.05±0.00
Mg (%)	0.16±0.01	0.19±0.01
K (%)	1.80±0.10	0.79±0.04
Na(ppm)	29.50±4.30	30.51±2.41
Fe(ppm)	408.67±46.59	426.23±40.82
Mn (ppm)	316.67±30.94	357.00±30.00
Cu (ppm)	1.72±0.37	0.86±0.30
Zn (ppm)	22.39±0.76	16.74±1.61

Sources: Lemma (2002)

2.14.2. Influence of altitude on mineral concentration of feeds

Aschalew *et al.* (2006) reported that altitude influences the mineral concentrations of feeds. In the higher and mid altitudes, the feeds were found to be deficient in Ca, P, Mg, Na, and K. During the wet and dry seasons from three altitudinal ranges of the central and western parts of Ethiopia, only 4.55% were found to be deficient in Ca. The phosphorus level was found to be sufficient only in 11% of the feeds analyzed. Out of the tested feeds, 31.82 % were found to be deficient in Mg content. In the lower altitudes Na was found to be absolutely deficient in all feeds as opposed to 84.96 and 96.97% of the high and medium altitudes, respectively.

Table 5: Macro mineral status of feed resources in the three altitudinal ranges (%)

Minerals	Requirement %	Higher altitude			Mid altitude			Low altitude		
		Deficient	Border line	Sufficient	Deficient	Border line	Sufficient	Deficient	Border line	Sufficient
Ca	0.20-0.82	6.06	65.15	28.79	27.27	72.73	-	-	30.00	70.00
P	0.16-0.38	42.11	48.12	9.77	54.55	42.42	3.03	40.00	60.00	-
Mg	0.12-0.18	32.56	24.81	42.64	36.36	27.27	36.36	10.00	10.00	80.00
Na	0.09-0.18	84.96	8.27	6.77	96.97	3.03	-	100.00	-	-
K	0.50-0.80	9.77	12.78	37.44	3.03	3.03	93.94	-	30.00	70.00

Source: Aschalew *et al.* (2006)

2.14.3. Influence of season on mineral concentrations of soil

The mineral concentrations in soils increase during the dry season because of high temperature and high evaporation that induce high level of air humidity (Mona, 2014). This author also reported that during dry season the concentrations of minerals increased in all tested soil samples. The distribution of exchangeable bases (ca, Mg, K, Na) showed decreased down the depths of the soil andthis might be due to the higher organic matter at the upper depths during the dry and beginning of rains. At these periods, there was little or no leaching of these cations (Fatubarin and Olojugba, 2014). At the peak rains, total exchangeable bases were low and decreased down the depths; this could be attributed to the elements being utilized by the regenerating plants (Hopkins, 1974).

Table 6: Soil macro-minerals concentration as related to season and location of collection

Element mg/Kg	**Critical value**	**Seasons**	**Locations**		
			I	II	III
Ca2+	250	Winter	419	380	484
		Summer	441	369	514
Mg2+	30	Winter	42	67	34
		Summer	46	31	46
K+	60	Winter	45	34	54
		Summer	48	38	70
Na+	62	Winter	60	41.5	44.4
		Summer	57.3	51.5	72

Source: Zafar *et al*. (2004)

2.14.4. Influence of altitude on mineral concentrations of soil

Climate may affect the mineral concentration in plant as shown by the deficiency of Zn in cool and wet season which is associated with insufficient solubility of Zn in soil (Reuter, 1975). Understanding spatial changes in soil nutrients is important, as they may differ markedly among identical locations subjected to natural and man-made disturbances. Vertical, horizontal and temporal distribution of nutrients in soils are controlled by a combination of factors viz, parent material, topography, soil management practices and rainfall. Similarly, land use patterns and vegetation play important role in soil nutrient transformations and fertility (Fatubarin and Olojugba, 2014).

2.15. Mineral deficiencies in animals

Mineral deficiencies and imbalances for herbivores were reported from almost all tropical regions of the world. These reports include both confirmed and highly suspected geographical areas of mineral deficiencies and toxicities in cattle. The mineral elements most likely to be lacking under tropical conditions are Ca, P, Na, Co, Cu, I, Se and Zn. In some regions, under specific conditions, Mg, K, Fe, and Mn may be deficient and excesses of F, Mo and Se are extremely detrimental (McDowell, 1997). Certain trace minerals deficiency affect immunity and may affect disease susceptibility in cattle. Selenium, Cu, Zn, Co and Fe have been lshown to alter various components of the immune system. Trace mineral deficiencies may also reduce the effectiveness of vaccination programs by reducing the ability of the animal's immune system to respond following vaccination (Jerry, 1995). Reported reproductive disorders associated with a copper deficiency in grazing ruminants include: low fertility associated with delayed or depressed oestrus, and long post-partum return to oestrus period; infertility associated with anoestrus and abortion (Corah and Ives, 1991). According to this study, an inverse relationship between serum copper levels and important reproductive parameters such as days to first service (56 vs. 70 days), services per conception (1.1 vs. 4.4) and days to conception (56 vs. 183) in dairy cows with high and low serum copper levels, respectively (McDowell, 1996). Calcium and P deficiency causes reduced appetite and milk yield, a decline in reproductive efficiency, poor feed utilization, lowered disease resistance, increased incidence of milk fever, reduce growth rate, osteoporosis and osteomalacia (NRC, 2001). Manganese deficiency in ruminants is associated with impaired reproductive function, skeletal abnormalities, and less than optimal productivity. Cystic ovaries, silent heat, reduced conception rates and abortions are reported reproductive effects. Neonates that are manganese deficient can be weak, small and develop enlarged joints or limb deformities (Jeffery and ZoBell, 2010).

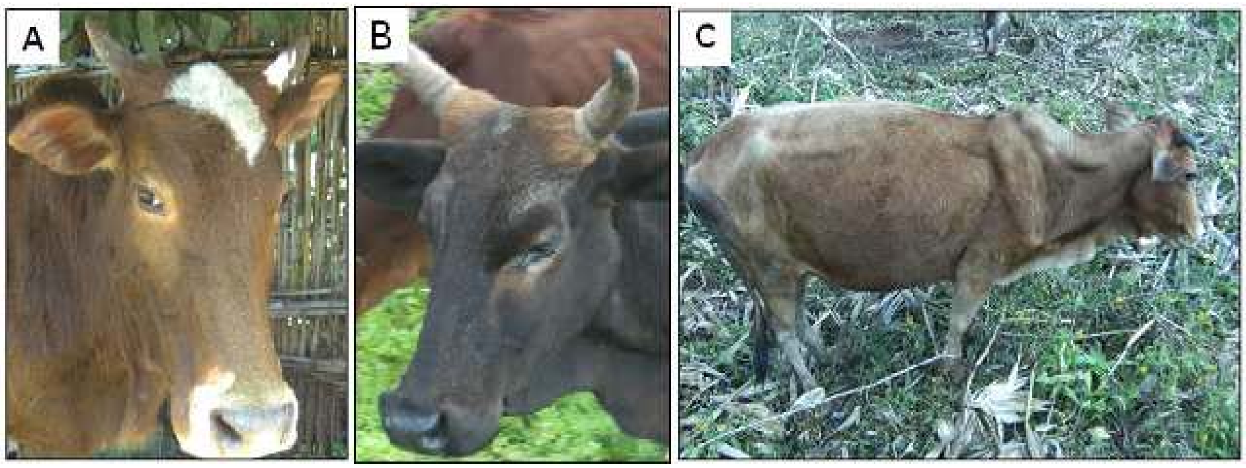

Figure 1: Indications for copper deficiency; A: depigmentation of red hairs around the eyes B: depigmentation of black hairs around the eyes and horns C: severe loss of hair color over the whole body, hair looks dull and kinky, diarrhea on the hindquarters and small posture.

Source: Thomas (2011)

2.16. Mineral status of livestock feeds in Ethiopia

In an experiment of feed samples collected by Aschalew *et al.*(2006), during the wet and dry seasons from three altitudinal ranges of the central and western parts of Ethiopia, only 4.55% were found to be deficient in Ca. The phosphorus level was found to be sufficient only in 11% of the feeds analyzed. Out of the tested feeds, 31.82 % were found to be deficient in Mg content. Among all minerals analyzed, Na was found to be the most deficient macro mineral in central and western parts of Ethiopia, the majority of the browse species, cereal straws and by-products being deficient to meet animal requirements. On the contrary, the K concentration was found to be adequate in most of the feeds analyzed (Aschalew *et al.,* 2006). Cereal straws were found to be deficient in P, Na and Mg, while straws of food legumes were highly deficient in P. Comparatively, less percentage of straws of food legume was categorized as Na deficient compared to the other feed types. Pasture grass and other feeds were found to be deficient in Na, P and Mg in relation to dietary requirements. A large proportion of feed samples were deficient in Cu and zinc. There were wide variations in the concentrations of these elements among the soil and feed samples (Khalili *et al.*, 1993). General trend indicated that most of the feeds of the dry season fell in the category of deficient to border line than that of the wet season feeds.

2.17. Mineral status of soil in Ethiopia

Most naturally occurring mineral deficiencies in livestock are associated with specific regions, and they are related to both soil mineral concentration and soil characteristics (McDowell, 1986). Lemma *et al*. (2002) reported that the levels of soil K, Ca, Mg, Fe, Mn, and Cu did not seem to limit pasture production in the mid-altitude of western Ethiopia. Soils, however, are seriously deficient in P and Zn and their amendment through fertilization may deserve some consideration. Since soils and native pastures in the uplands contained lower mineral levels, cattle that have no access to bottomland grazing areas are most vulnerable to mineral deficiencies. Leaching or translocation of mobile elements by rainwater to the root system, however, does occur with the advance of the season (Lemma *et al.*, 2002).

3. MATERIALS AND METHODS

3.1. Description of the study area

3.1.1. Location and area coverage

The study was carried out in Meta Robi district, West Showa Zone, Oromia Regional State, Ethiopia. The total human population of the district is 166,472 (male= 82,482 and female= 83,990) (CSA, 2013). The district is located at 101 km west of the capital city of the country. The altitude of the district ranges from 1,376–2,904 meter above sea levels (masl). The total land area of the district is about 93,769 ha (crop land = 51,762.9 ha, grazing land = 11,775.94 ha, forest land = 6,792.75 ha and land used for other purposes= 23,437.4) (Meta Robi district Agricultural Office annual report, 2013/14). The district has 41 rural kebeles and 5 peri-urban towns.

3.1.2. Climatic condition and topography

The minimum and maximum temperatures of the district are 15 and 31^0C, respectively. The district receives average annual rainfall ranging from 750–1,300 mm (highland=950-1300, midland=800-950 and lowland=750-800 mm). The main rainy season is from June to end of September. The topography of the district is characterized to be flat land (60%), valley (8%), mountains (9%) and rugged (23%) (Meta Robi district Agricultural office annual report, 2013/14).

3.1.3. Soil types

The soil types of the district are classified in to Humic Nitosols (one of the best and most fertile soil, can suffer acidity and P-fixation, and it becomes very erodible), Eutric Vertisols (soils with 30% or more clay, cracking when dry and swelling when wet, extremely difficult to manage, easily degraded and very high natural chemical fertility if physical problems overcome), Haplic Luvisols (greatly affected by water erosion and loss in fertility, nutrients are concentrated in topsoil and they have low levels of organic matter), Rendzic Leptosols (very shallow soil over hard rock or highly calcareous material, but also deeper soils that are extremely gravelly and/ or stony) and Vertic cambisols (have relatively good structure and chemical properties and not greatly affected by degradation processes) (FAO, 1974).

3.1.4. Occupation and farming system

The majority of the population of the district is dependent on agriculture.The farming system is characterized by mixed crop-livestock production system. The district is characterized by rain-fed production system of a wide-range of cereals and pulses and livestock husbandry practices. The livelihood of the farmers was depends on the production of cereals, pulses and oil crops along with livestock that is kept on natural pasture and crop residues (FAO, 2011).

3.1.5. District and Kebele selection

The district was selected due to the presence of relatively large number of animals, availability of large grazing and crop lands and marginality of the district to most technological interventions as compared to the neighboring districts. Out of 41 rural kebeles, 9 kebeles representing upper altitude (3 kebeles), mid altitude (3 kebeles) and lower altitude (3 kebeles) were selected using a stratified random sampling method in consultation with the districts' livestock expert based on the Ethiopian agro-ecological classification (Dereje and Eshetu, 2011).

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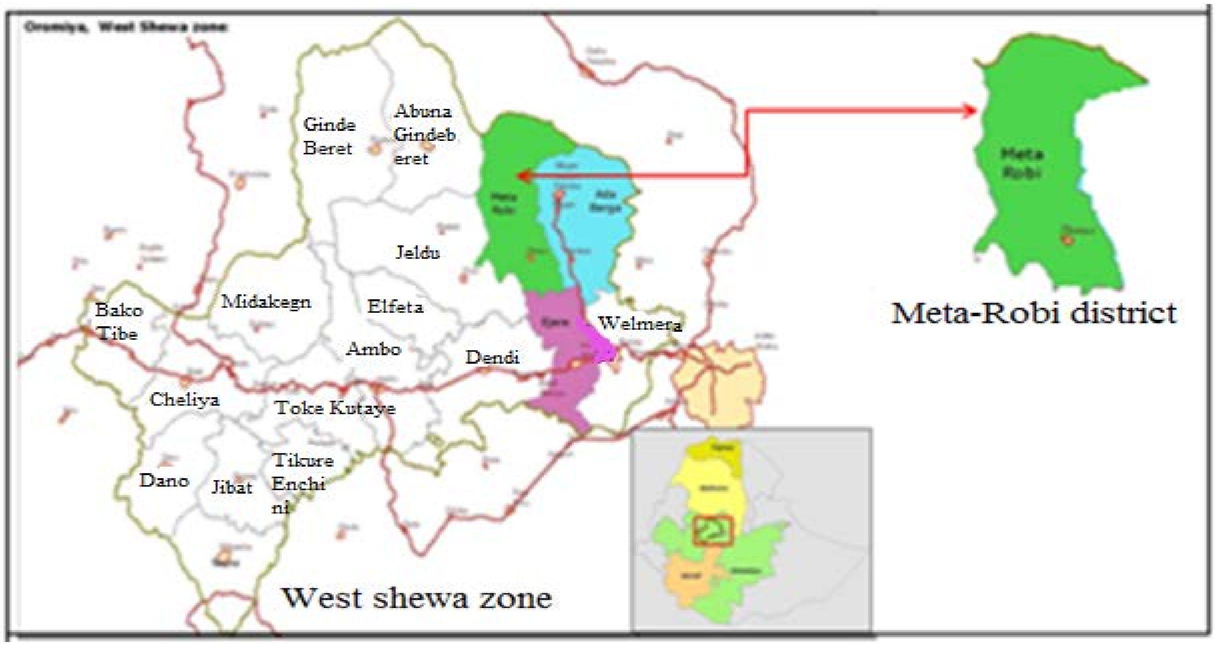

Figure 2: Map of West shoa zone (left) and Meta Robi district (right) (LIVES, 2012)

3.1.6. Farmers selection and Data collection

A total of 90 households from 9 kebeles (10 hh from each kebele) were selected randomly and interviewed independently. A pre-tested questionnaire was used to collect data by interviewing individual farmers at their farm gates. In the prepared questionnaire, there were single and multiple response questions. Single response questions were those questions where the sampled household would have a single response and multiple response questions were questions where the individual household might provide more than one answer for given question. In case of the latter, the percentage of responses (respondents) would be greater than 100%.

3.2.Assessment of feed resources availability

To determine the availability, sources and types of livestock feed in the district, data were collected both from primary and secondary sources. Secondary sources of data on climate, soil types and characteristics, topography, agro-ecology, livestock population and crop production potential of the district were collected by reviewing different documents (eg. Annual reports) from relevant district offices like livestock production and health agency, agriculture and land management. This was followed by group discussion with key informants containing 8-12 individuals including men, women and young households, livestock expert and development agents (Appendix table 5). One group discussion was carried out in each agro-ecology of the study district. Based on the outcomes of the two (literature review and group discussions) a semi-structured questionnaire was prepared to elicit information from the sample households (Appendix table 4). Primary data on household size, household herd size, land holding and utilization pattern, major feed resources, production of grain and crop residues, seasonality of feed resources, constraints in feed production, conservation, transportation and supply were obtained from the questionnaire survey during the course of the study . The survey was conducted by the researcher and development agents of the respective kebeles between March-May 2014.

3.2.1. Estimation of annual feed availability

The quantity of feed DM obtained annually from different land use types was calculated by multiplying the hectare of land under each land use types by its conversion factors. A Conversion factors of 2.0, 0.5 and 0.7 tons DM/ha/year were used for natural pasture, aftermath grazing and forest land, respectively (FAO, 1984). The quantity of available crop residues produced by farmers was estimated by converting crop yield to straw yield (Kossila, 1984; FAO, 1987; Kossila, 1988; De Leeuw *et al.,* 1990). Accordingly, for a ton of wheat, barley and *tef* straws, a multiplier of 1.5 was used, for faba bean and field pea a multiplier of 1.2 was used (FAO, 1987), for noug seed and linseed a multiplier of 4.0 was used (Kossila, 1984; FAO, 1987). For maize a multiplier of 2.0 (De Leeuw *et al.*, 1990) and for sorghum a multiplier of 2.5 was used (Kossila, 1988). The total quantity of potentially available crop residues for animal consumption was estimated by multiplying the crop residue yield by 90% assuming that 10% wastage of the feed mostly occurs during feeding and/or used for other purposes (Adugna and Said, 1994).

3.2.2. Estimation of livestock population and Dry matter requirement of the animals

The total livestock population of the district and the interviewed households was converted to tropical livestock unit (TLU) as recommended by Jahnke, (1982) for local animals. Therefore, the conversion factors for local oxen and bulls, cows, heifers and calves were 1, 0.7, 0.5 and 0.2, respectively. For sheep and goats conversion factors of 0.1, horses 0.8, donkeys 0.5, mules 0.7 and poultry 0.01 was used. The DM requirement of an animal was calculated based on the daily DM requirement of 250 kg dual purpose tropical cattle (an equivalent of one TLU) for maintenance requirement that needs 6.25kg/day/animal or 2281 kg/year/animal (Jahnke,1982).

3.2.3. Annual feed balance

To determine the annual feed balance; total livestock feed produced from different feed sources, total livestock units in the district and their annual maintenance requirement were estimated. The annual maintenance requirement of the animals was calculated and subtracted from the total livestock feed produced per year. If the amount of feed produced per year is above maintenance requirement of the animals, feed is in excess of maintenance requirement of the animals otherwise there is deficiency of livestock feed in the district.

3.3.Determination of mineral status and pH

For mineral status determination, feeds and soil samples were collected in two seasons: dry (Mid of March) and wet (End of September) and delivered to Haramaya University central laboratory for the analysis of macro minerals Calcium (Ca), Phosphorus (P), Potassium (K), Sodium (Na), Magnesium (Mg) and Sulfur (S) and micro minerals Copper (Cu), Iron (Fe), Manganese (Mn) and Zink (Zn). The pH of the soil was measured in Ambo University Chemistry laboratory.

3.3.1. Feed Samples Collection

Natural pasture samples were collected during dry and wet seasons from 3 altitude (upper, mid and lower) zones to represent each altitude zone of the district. Three kebeles from each altitude were selected based on grazing land availability and livestock production potential. From each kebele four privately owned grazing lands were selected in consultation with the owner of the land and development agents of the respective kebeles. The selected grazing land was used for grazing purpose for several years and protected from grazing for few months during wet season to initiate regeneration of pasture and used for hay production.

3.3.2. Sampling techniques

Natural pasture samples from private grazing land were harvested randomly from 10 quadrates per grazing land using a 0.5x0.5 m^2 quadrates at stubble height (5cm) to mimic natural grazing by using sickle. After removing the non-edible plant species, all sub-samples harvested from the same grazing lands were thoroughly mixed to make one composite sample of one kilo gram, leveled and stored in the sample bags. The samples were dried by air in order to prevent spoilage of the samples before being placed in the oven.

3.3.3. Soil Samples collection

Soil samples were collected from upper, mid and lower altitude zones of the same kebeles and grazing lands where the sampled feeds were growing and harvested, during dry (Mid of March) and wet (End of September) seasons of the year. Twenty soil sub-samples per grazing land were collected in a zigzag manner at a depth of 20 cm using a soil auger. After thoroughly mixing of sub-samples, one kg composite soil sample was taken from each grazing land. Four composite soil samples for dry and 4 composite soil samples for wet seasons were collected from each kebele and a total of 36 composite soil samples for dry and 36 for wet season were collected from the study areas.

3.3.4. Feed sample preparation and analysis

A representative sample of 1 kg for each sample was dried in a hot air oven at 65 ^{0}C for 72 hours and ground in a Willey mill to pass through 1-mm sieve and kept in tightly stoppard bottles until the analyses were carried out. The organic matter of the samples was destroyed by burning the samples at a temperature of 450 ^{0}C for 4 hours (Dry ashing method) in the furnace (Bock**,** 1979). Calcium, Mg, Zn, Mn, Cu and Fe were determined by using Atomic Absorption Spectrophotometer (210VGP Atomic Absorption Spectrophotometer USA, 1992). The concentration of P and S were determined by Ultraviolet (UV) **S**pectrophotometer **(**UV-T80 +UV/VIS Spectrometer PG Instrument Ltd) and Na and K were determined using flame photometer (ELICO SL 378, India). The macro and micro mineral concentrations of the feeds were categorized into deficient or sufficient based on the mineral requirement of dairy animals (NRC, 1989) and (Suttle, 2010).

3.3.5. Soil sample preparation and analysis

Soil samples were dried under shade before placed in the oven and then dried at 65 ^{0}C for 72 hours in the oven and ground in a Willey mill to pass through 2 mm sieve. Exchangeable bases (Ca, Mg, K and Na) were extracted by ammonium acetate (1N NH4OAc) at pH 7.0 and micronutrients (Fe, Cu, Zn and Mn) were extracted by Diethylene Triamine Pentaacetic Acid (DTPA) as described by Sahlemedhin and Taye (2000). Calcium, Mg, Zn, Mn, Cu and Fe were determined by using Atomic Absorption Spectrophotometer (210VGP Atomic Absorption Spectrophotometer USA**,** 1992). Sodium and K were determined using flame photometer (ELICO SL 378, India). The concentration of P and S were determined by Ultraviolet (UV)-spectrophotometer **(**UV-T80 +UV/VIS Spectrometer PG Instrument, Ltd) following extraction by Bray-II and digestion methods, respectively. Concentrations of the minerals in the soil were compared with the critical levels of mineral elements required for plant growth (Mtimuni, 1982; Katyal and Randhawa, 1983; Rhue and Kidder, 1983; McDowell, 1985; Pam and Brian, 2007).

3.3.6. Soil pH determination

The pH of the soil samples collected from each grazing land was measured separately in Ambo University Chemistry laboratory. It was measured in the supernatant suspension of 1:2.5 soils: water ratio (Baruah and Barthakur, 1997). The soil suspension was shaken for half an hour using orbital shaker set at 150 RPM (Revolution Per Minute).The pH of the soil suspension was measured using pH meter (CP-501, Elmetron-with automatic temperature compensation), that was calibrated using buffer pH at 4.0, 7.0 and 9.0 that bracketed the pH of the soil suspension.

3.4.Statistical analysis

3.4.1. Household survey data

The survey data was stratified into altitude zones, coded and analyzed using the Statistical Package for Social Sciences (SPSS version 17) for windows. Means, percentages and standard errors of various parameters were calculated for each altitude zones of the study district.

3.4.2. Mineral concentration in feed and soil samples

The analysis of natural pasture and soil mineral concentration data was conducted with the aid of Statistical Analysis System (SAS, 2002). The mean mineral concentration of soil and natural pasture from upper, mid and lower altitudes were compared statistically using General Liner Model (GLM) procedure of SAS. Mean separation for mineral element concentrations of natural pasture and soil was compared using Tukey's-test and significance level were considered at $P<0.05$.

3.4.2.1. Statistical model used:

For determination of the mineral status of the feed and soil samples the following statistical model was used:

$$M_{ij} = \mu + A_i + S_j + (A*S)_{ij} + e_{ij},$$

Where **Mij** = Measured parameter

μ= Over all mean

Ai= the effect of altitude on mineral concentration

Sj = the effect of sampling seasons on mineral concentration

(A*S)ij = the interaction of Altitude and Sampling season and

eij = random error.

4. RESULTS AND DISCUSSION

4.1. Socio-economic characteristics of the respondents

4.1.1. Household characteristics

The household characteristics of the respondents are presented in table 7. Overall, in the present study, about 79% of the respondents were male and 21% female headed households. The percentage of male and female headed households ranged from 73.3 to 83.3 and 16.7 to 26.7%, respectively. The average family size of the respondents in the upper, mid and low altitudes was 5.26, 6.36 and 6.63, respectively. In the mid and low altitudes, the average family size was relatively higher than upper altitude and this might be due to difference in farming systems and family planning program among farmers. The overall average family size in the study district is 6.08 individual ranging from 1-17. Generally, in the study district, the average family size of the respondents is 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 respondents in the three altitudinal zones is similar ranging from 47 to 50 years. The overall average age of the respondents in the study district is 48.1 years ranging from 25 to 75 years.

Table 7: Household characteristics of the respondents in the study district

Characteristics		Upper	Mid	Lower	Overall
Sex of the house hold	Male	73.3%	83.3%	80%	78.9%
	Female	26.7%	16.7%	20%	21.1%
Age of the household (yr)		47.73±13.34	49.90±11.39	46.66±13.37	48.10±12.66
Family member of the household		5.26±2.42	6.36±2.32	6.63±3.56	6.08±2.85

Of the sampled households in the study district, about 38.9, 23.3, 22.2, 7.8 and 7.8 % were illiterate, read and write only, elementary, junior secondary and secondary school, respectively (Figure 3). The high percentage of illiterate compared to the other categories can hinder in the adoption of agricultural technologies in the study area. In lower altitude, farmers are forced to stop education at elementary school mostly because of distance from school and other socio-economic factors like wealth difference of the farmers.

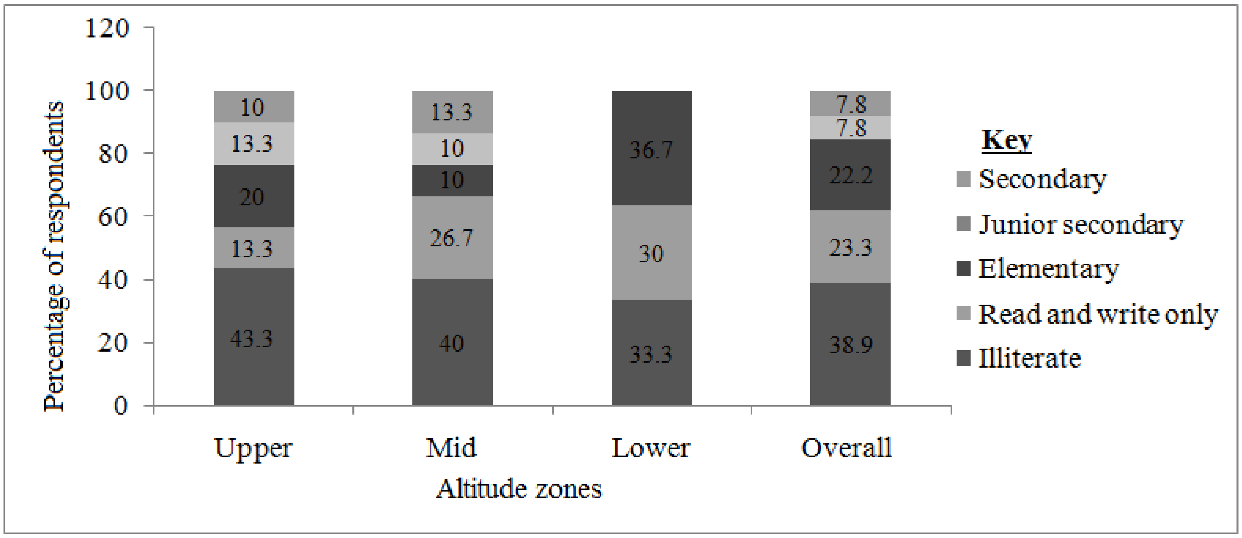

Figure 3: Educational status of respondents in the study district

4.1.2. Landholding and land use pattern of the households

The total land holding of the respondents was the lowest in low altitude (2.7 ha/HH) as compared to 4.5 ha/hh in the upper and 4.2 ha/hh in mid altitudes (Figure 4) this is mostly due to small amount of total land and large human population in lower altitudes. The size of land allocated for home stead in the district was in the range of 0.37-0.59ha/HH. In the study district, the average total land owned by the households was 3.8 hectares ranging from 0.5 to 12 ha. The average landholding of the respondents in the study district is higher than the average national landholding size (0.96 ha/hh) and Oromia region (1.15 ha/hh) (CSA, 2011). The average land size allocated for crop production varied between 1.66 to 2.27 ha while that of grazing land was 0.77 to 1.45 ha (Figure 4). In general, the households in the study district allocated about 2.05 ha (53.1%) for crop production and 1.22 ha for grazing of livestock (31.60%). The land allocated for crop production and animal grazing in the lower altitudes was small as compared to upper and mid altitudes and this could be due to the availability of smaller size of land per household in the lower altitude. 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. The land allocation differences in these neighboring districts might be due to differences in farming system.

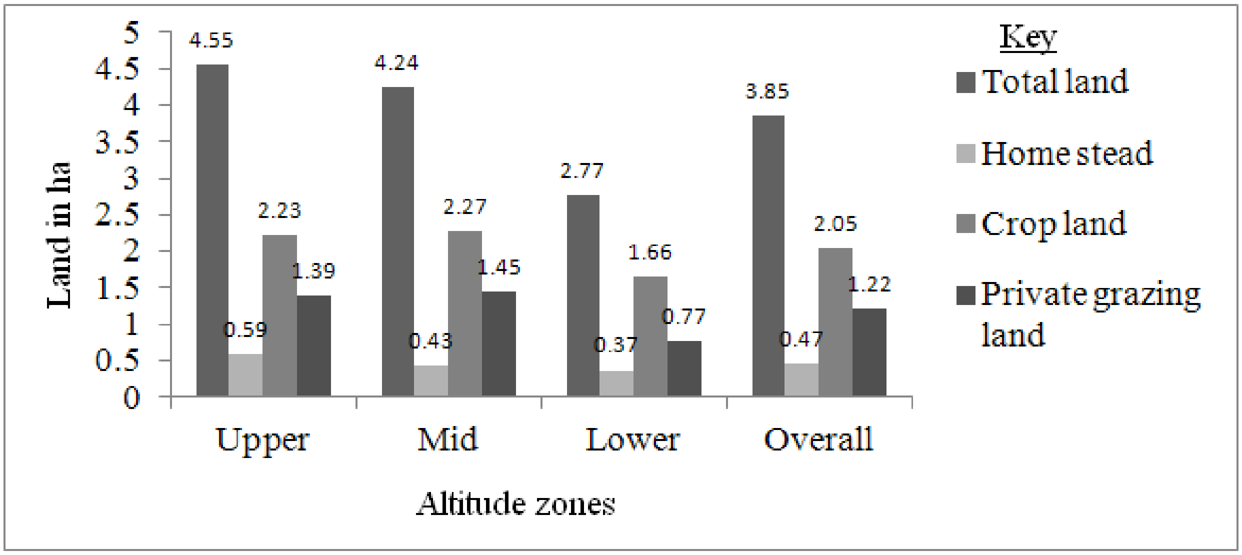

Figure 4: Land holding and use patterns of the sampled households in Meta Robi district

4.1.3. Livestock population, herd composition and purpose of livestock rearing

The total populations of livestock in the district were estimated to be 171,177.88 TLU. As shown in table 8, cattle comprised 82.11% of the total TLU of the livestock population in the district. About 36.32% of the cattle were cows followed by oxen (27.19%), heifers (20.39%) and bulls (16.08%). In agreement to the current study, in highland production system of the country, cattle comprised 92% of total TLU and about 37% of the cattle herd was cows and steers (18%) (Funte *et al.*, 2010). In the same report, the percentage of oxen (19%) and heifers (7%) were contrasting with the current study mainly due to the purpose of the farmers keeping livestock vary according to production system. The overall average TLU of livestock per household in the study district is 7.97, 0.74, 0.46, 0.78, 1.44, 0.8 and 0.07 for cattle, sheep, goats, donkeys, horses, mules and poultry, respectively. Contrary to the current study, the average TLU of cattle (5.35), sheep (0.49), goats (0.03), donkeys (0.22) and poultry (0.02) in Jeldu district were reported (Bedasa, 2012). These differences among neighboring districts might be due to the farming system and/or gazing land availability differences. The large number of sheep (0.74 TLU) than goats (0.46 TLU) owned per HH might indicate the fitness of these animals in that production system as the area is suitable for sheep production.

In the study district, about 70% of the respondents indicated that the total number of livestock and herd composition was declining from time to time. Agajie *et al.* (2001) also reported that 73% of the sample farmers in north and west shoa zones indicated a decline in livestock population in the past two decades. In the current study, the major reasons responsible for declining livestock number are, shortage of grazing land, population growth and expansion of crop land, shortage of feeds and water and animal diseases. Samson and Frehiwot (2014) reported that in the highland production system of Ethiopia where crop production is dominant the farmer requires cattle mainly for tillage and herd size may have to be reduced due to land or feed shortage.

Table 8: Livestock population of Meta Robi district

Animals species	Population	TLU equivalent *	Total TLU
Cattle			140,561.3
Cow	72,944	0.7	51,060.8
Oxen	38,222	1	38,222
Heifer	57,333	0.5	28,666.5
Bulls	22,612	1	22,612
Sheep	59,321	0.1	5932.1
Goat	58,105	0.1	5810.5
Donkey	11,181	0.5	5590.5
Horse	15,213	0.8	12,170.4
Mule	590	0.7	413
Poultry	70,008	0.01	700.08
Bee Colonies	20,182	-	-
Total			171,177.88

* Jahnke (1982)

Source: 2013/14 Annual report of Meta Robi district Livestock production and health Agency.

The main purpose of cattle rearing in the study district was for draught power and income generation (100%). Livestock generate income for the farmers directly by selling the animal or through the production of milk and milk products and hides and skins. In the study district, equines were used for transportation (86.7%) and income generation purposes (56.7%). In agreement with the current finding, 68% of the respondents in Western Harerghe indicated that they rear cows and heifers for milk and cash generation through sale of milk and live animals, while oxen and bulls for cash generation and draught power (96.8%) (Dereje and Tesfaye, 2008).

In the study district, (80%) and (78.9%) of respondents indicated that small ruminants are used for income generation and home consumption (eg. meat), respectively. This finding is in agreement with the report of Dhaba *et al.* (2012) who indicated that about 93% of the respondents keep small ruminant in Ilu Abba Bora, Ethiopia for income generation. Dereje and Tesfaye (2008) reported that in western Harerghe, farmers rear goats for milk and cash source (57.6%) and meat (41.6%). Sheep was mainly used as a source of cash (66.4%) and as both meat and cash (30.4%) and for home consumption (3.2%).

In the current study, chickens are the source of income for the household in upper (56.7%), mid (66.7%) and lower altitudes (89.7%) and used for home consumption in the upper (56.7%), mid (56.7%) and lower altitudes (64.3%). Generally, in the study district, chickens were used for income generation (70%) and home consumption purposes (57.8%). According to Dereje and Tesfaye (2008), almost all the respondents in Western Harerghe kept poultry for egg production and sale which is much higher than the present result.

Table 9: Mean local cattle holding size of the sampled households in three altitude zones of Meta Robi district in TLU

Altitudes	Oxen		Cows		Bulls		Heifers		Calves	
	Mean	SE	Mean	SE	Mean	SE	mean	SE	mean	SE
Upper	3.00	2.13	2.33	1.51	1.92	1.29	1.05	0.50	0.50	0.3
Mid	2.63	1.35	2.17	1.14	1.74	0.93	1.27	0.56	0.32	0.2
Lower	2.36	0.91	1.35	0.70	2.09	0.83	0.93	0.50	0.30	0.16
Overall mean	2.66	1.54	1.95	1.23	1.92	1.05	1.09	0.55	0.35	0.24

Table 10: Small ruminants, Equine and Poultry holdings of the respondents in TLU

Species	Upper		Mid		Lower		Overall mean	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Sheep	0.98	0.82	0.65	0.25	0.31	0.09	0.74	0.95
Goats	0.37	0.26	0.45	0.32	0.47	0.32	0.46	0.31
Donkey	0.85	0.32	0.77	0.29	0.72	0.36	0.78	0.33
Horses	1.67	0.97	1.12	0.76	1.00	0.4	1.44	0.9
Mule	1.19	0.45	-	-	0.80	0.00	0.80	0.00
Poultry	0.06	0.03	0.04	0.02	0.08	0.03	0.07	0.03

4.2. Major livestock feeds in the district

The major feed resources in the district were natural pasture grazing (58.9%), crop residues such as wheat straw (42.4%), barley straw (30%), hay (21.1%), *Atella* (18.9%) and crop aftermath (7.8%) (Table 11) that are similar to the feed resources in most highlands of Ethiopia (Lemma *et al.*, 2002; Alemayehu, 2003; Tolera *et al.*, 2012). Generally, natural pasture and crop residues were the dominant feed resources in the study district but agro-industrial by products such as noug seed cake, linseed cake, molasses and brewery by products, non-conventional feed and improved forage were uncommon and rarely used. The major feed types in the upper altitudes of the district are natural pasture, wheat straw, *teff* straw, maize stover and hay whereas in mid altitude natural pasture, *teff* straw, wheat straw and barley straw in their descending order. In lower altitude *teff* straw, wheat straw, sorghum and maize stover contributed the most in their descending order.

4.3. Feed resources during dry and wet seasons

In the study district, during dry season, 90% of the respondents use crop residues as number one feed resource followed by hay (58.8%) and stubble grazing (56.1%) (Table 12). Majority of the respondents in Ganta Afeshum Woreda Eastern zone of Tigray indicated that, crop residues from wheat, Maize, barley, bean, and peas as well as “atella” are important feed sources especially during the dry season when availability of pasture is low (Berihu *et al.,* 2014). According to Abate *et al.* (2010) straw from maize, sorghum and teff was used mainly during the dry season in south eastern parts of the country. Contrary to the current study, Tesfaye (2008) reported that the major dry season feed resources for cattle in Metema district were natural pasture (55.7 %), crop residues (20.7%), stubble (14.3 %) and hay (9.3 %) and this is mostly due to agro- ecological differences between the two districts. In wet seasons, all the respondents (100%) in all altitudes use natural pasture followed by hay and fodder to feed their animals (Table 12).

Table 11: Major feeds supplied to livestock in Meta Robi district

Types of feed	priority levels								Rank
	1st	2nd	3rd	4th	5th	6th	7th	8th	
Pasture grazing	58.9%	10%	6.7%	2.2%	1.1%	1.1%	-	-	1st
Wheat straw	15.6%	42.4%	14.4%	4.4%	2.2%	1.1%	-	-	2nd
Barley straw	-	5.6%	30%	12.2%	3.3%	-	-	-	3rd
Hay	4.4%	13.3%	8.9%	21.1%	3.3%	-	-	-	4th
Atella	-	1.1%	-	6.7%	18.9%	12.2%	7.8%	5.6%	5th
Crop aftermath	-	-	5.6%	10%	11.1%	7.8%	7.8%	1.1%	6th
Maize stover	-	5.6%	6.7%	14.4%	7.8%	3.3%	3.3%	-	-
Sorghum stover	1.1%	2.2%	6.7%	4.4%	5.6%	4.4%	1.1%	1.1%	-
Teff straw	20%	20%	15.6%	12.2%	12.2%	2.2%	1.1%	-	-
Wheat bran	-	-	1.1%	-	2.2%	-	1.1%	2.2%	-
Oats	-	-	-	-	8.9%	-	3.3%	2.2%	-
Noug cake	-	-	-	-	1.1%	1.1%	-	-	-
Molasses	-	-	-	-	3.3%	7.8%	2.2%	-	-

Table 12: Dry and wet seasons feeds in the study district

Feed type	Dry season				Wet season			
	1st	2nd	3rd	4th	1st	2nd	3rd	4th
Crop residues	90%	8.25%	-	-	-	30.6%	20%	-
Hay	10%	58.8%	21.05%	-	-	36.7%	31.4%	-
Fodder	-	3.52%	3.5%	9.5%	-	8.16%	21.70%	13.3%
Stubble grazing	-	24.7%	56.1%	9.5%	-	2.04%	-	-
Concentrates	-	2.35%	7.01%	23.8%	-	-	2.85%	6.66%
Natural pasture	-	-	1.75%	-	100%	-	-	-

4.4. Seasonal availability of feeds

The respondents classified months of the year according to feed availability (Figures 5). According to this study in overall study area, animal feed was available in excess in the months of September (86.7%), October (86.7%) and November (74.4%).This excess availability of feeds during these months was associated with the availability of natural pasture grazing, hay production, crop residues and aftermath grazing. Feed was adequately available in the months of December (52.2%), January (54.4%), June (46.7%), July (52.2%) and August (51.1%). This can be related to the availability of hay, crop residues and aftermath grazing in the months of December and January and natural pasture in the months of June, July and August. 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 dwindles. According to his study, during the dry season, 36.43 and 63.57% of the respondents replied that feed was adequate and inadequate, respectively whereas during wet season 50, 7.14 and 42.86% of the respondents responded that feed was adequate, inadequate and abundant, respectively. In the current study, 83.3%, 95.6%, 96.7% and 96.6% of the respondents indicated that February, March, April and May were classified as feed shortage months, respectively. In these months, the availability of natural pasture, hay, crop residues and aftermath grazing is reduced. The same result was reported by Tessema *et al*. (2003) that the critical feed shortage months in Belesa Woreda were from January to the end of June. Therefore, supplementing the animals with agro-industrial by products or provision of improved forages during dry periods is critical for better livestock production.

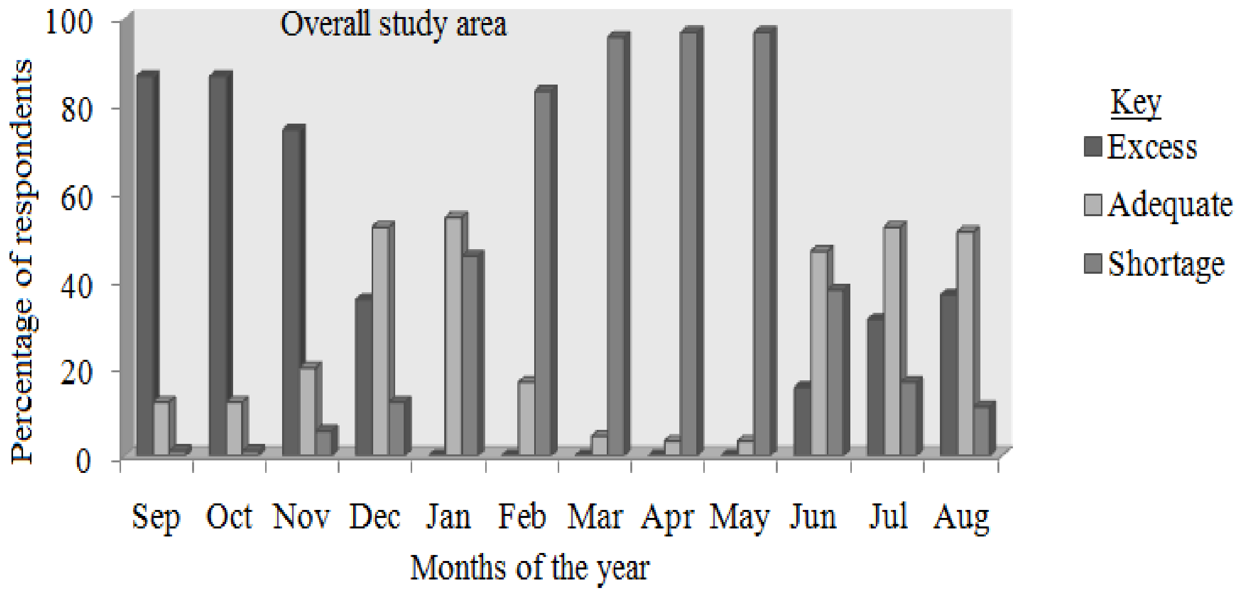

Figure 5: Responses of the sampled households regarding feed availability by months

4.5. Feed availability and sources

In the study district, the different sources of feeds for livestock are presented in figure 6. About 46.7% respondents had their own natural pasture land, 42.2% were both rented in and had own pasture land and the rest purchase/rented natural pasture land from other farmers for their livestock feed production. As indicted above, large percentage of respondents rented pasture land for livestock feed production implying that their own pasture land alone cannot support their livestock feed requirement. In the lower altitude, the majority of respondents had their own pasture land than in the two altitude zones but this does not mean that grazing land holding of that area is greater than the two altitudes.

Hay was commonly produced by respondents (Figure 6). Fifty eight percent of the farmers in the study district replied that hay is harvested from their own pasture land. In the upper, mid and lower altitudes, most respondents (53.3, 50 and 72.4%) produced hay on their own land whereas 6.7, 20 and 10.3% of the respondents in upper, mid and lower altitudes, purchased hay from local farmers, respectively. The rest 40, 30 and 13.8% of respondents in upper, mid and lower altitudes, produce hay both on their own land and purchased from other farmers, respectively. Fekede *et al.* (2013) reported that the majority of the respondents in Sululta (66.7%) and Ejere (58.3%) produce hay on their own land. In the current study, 12.2% purchased/rented this feed from others, 27.8% both harvest from their own land and purchased from others. The major reason for low amount of contracting hay in the study areas might be due to the availability of their own lands for hay production and/or poor market access as compared to other areas.

About 90, 76.7 and 93.3% of the respondents in the upper, mid and lower altitudes produced crop residues by themselves, respectively (Figure 6). The majority (86.7%) of the respondents in the study district obtained crop residues from their crop land. This indicates that crop residues marketing is not a common practice in the study area because crop residues was produced by the respondents in large quantity as compared to hay.

As indicated in figure 6, 56% of the respondents purchased agro-industrial by products for their livestock but 43.9% were not using it due to unavailability and high price of the products. Generally, in the current study, utilization of agro–industrial by products is not common as compared to natural pasture, hay and crop residues.

Improved forages were either own produced or not used by the respondents (Figure 6). Of the respondents in the upper, mid and lower altitudes, 70.4, 76.9 and 68% were not using improved forages due to unavailability of this feed type in their areas. This finding indicates that production and utilization of improved forages is very low so that intervention should be made to reverse this situation. Among the interventions, establishment of nursery sites for improved forge multiplication could bring improvements in the dissemination and utilization of this feeds as such practices have brought changes in other areas.

The use of “atella” (local alcohol waste) in the feed of livestock is significant and therefore, the majority of the respondents in upper (69.9%), mid (60%), lower altitudes (73.1%) and 69.8% of respondents in the study district were producing this feed by themselves (Figure 6).

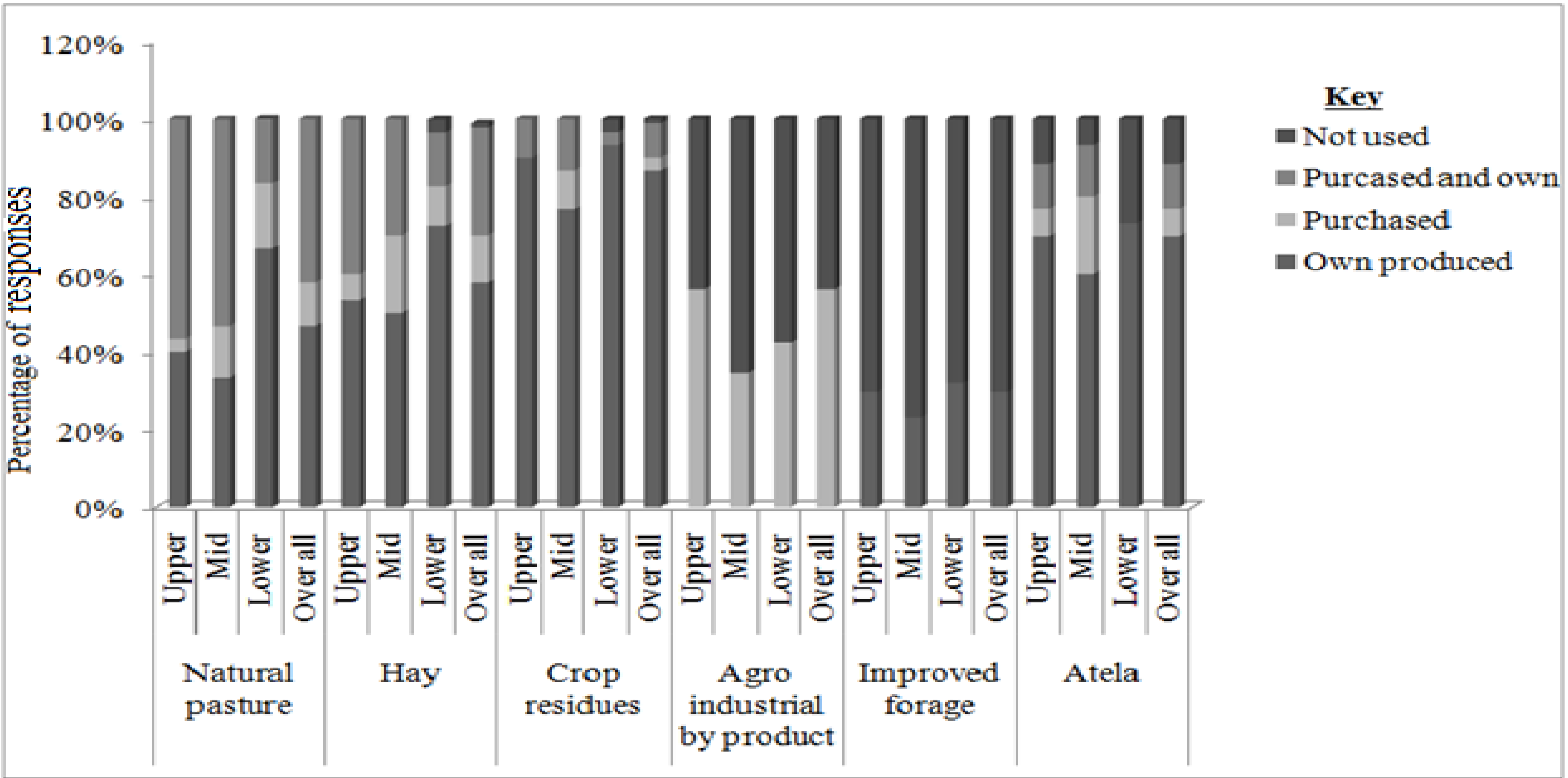

Figure 6: Feed sources in Meta- Robi district

4.6. Improved forages, shrubs and trees production and utilization

About 74.4% of the sampled households in the district did not have improved forages, shrubs or trees on their farm land as animal feed source (Table 13). Belay *et al.* (2012) reported that all households (100%) interviewed in Dandi district, west shewa zone did not cultivate improved forage species for their livestock production. In the same report, it was observed that around homesteads of some households, there was Sesbania tree as life fence, but farmers did not feed to their animals because of lack of knowledge. In addition, in the Ethiopian highlands, apart from their use in a limited number of specific situations, farmers have not benefited the advantage of multipurpose fodder trees can offer. In most cases farmers quit growing fodder trees when the projects terminated from the area (Abebe, 2008). In the study district, the major reasons for not planting improved livestock feeds include shortage of land (42.4%), shortage of forage seeds (24.3%), lack of awareness (26.4%), unevenness of rain fall (5.6%) and lack of interest of farmers (1.1%) (Table 13). This shows that farmers do have an interest to grow improved forage crops but other factors were hindering its production.

Table 13: Improved forage production and factors influencing its production and utilization in Meta-Robi district

Parameter	Upper altitude	Mid Altitude	Lower altitude	Overall areas
Do you have improved forages				
Yes	13.79%	26.7%	33.3%	25.6%
No	86.20%	73.3%	66.7%	74.4%
Reasons for not planting improved forages				
Shortage of land	29.62%	53.3%	44.4%	42.4%
Shortage of forage seed	18.51%	36.7%	17.8%	24.3%
Unevenness of rainfall	-	-	16.7%	5.6%
Lack of awareness	48.14%	10%	21.1%	26.4%
Lack of interest	3.70%	-	-	1.1%

4.7. Communal grazing land availability

In the upper, mid and lower altitudes, 26.7, 43.3 and 16.7% of the respondents, respectively replied that there was communal grazing land in their area (Table 14). In general, only 28.9% of the respondents in the district reported the presence of communal grazing land in their area and 84.8% of the respondents indicated that communal grazing land was decreasing, 6% increasing and 9.1% said that there was no change on communal grazing land size. Similar to the current study, WOCAT (2012) reported that communal grazing areas were increasingly being converted into cropland due to rapid population growth. This has led to enormous pressure on the little remaining grazing land, through overstocking of animals, and thus overgrazing, resulting in considerably decreased productivity of communal grazing land. Generally, the size of communal grazing land in the study district is decreasing from time to time and this indicates that the quantity of livestock feed obtained from this source was also decreasing. Respondents in the study district reported that, allocation of communal grazing lands for landless youths and expansion of crop lands were the major reasons for decreasing the size of communal grazing land in their respective area.

Table 14: Communal grazing land availability and its status

Is there communal grazing land in your area	Upper altitude	Mid altitude	Lower altitude	Overall mean
Yes	26.7%	43.3%	16.7%	28.9%
No	73.3%	56.7%	83.3%	71.1%
Status of communal grazing land				
Increasing	-	-	16.67%	6.06%
Decreasing	75%	100%	75%	84.84%
No change	25%	-	8.33%	9.09%

In the study district, different types of communal grazing lands were observed of which 65.18, 25.92, 6.67 and 2.22% of the respondents indicated that the communal grazing land was open grass land, bush covered, tree covered and swampy land type, respectively (Figure 7). In mid altitude, only open grass land type of communal grazing land was available.

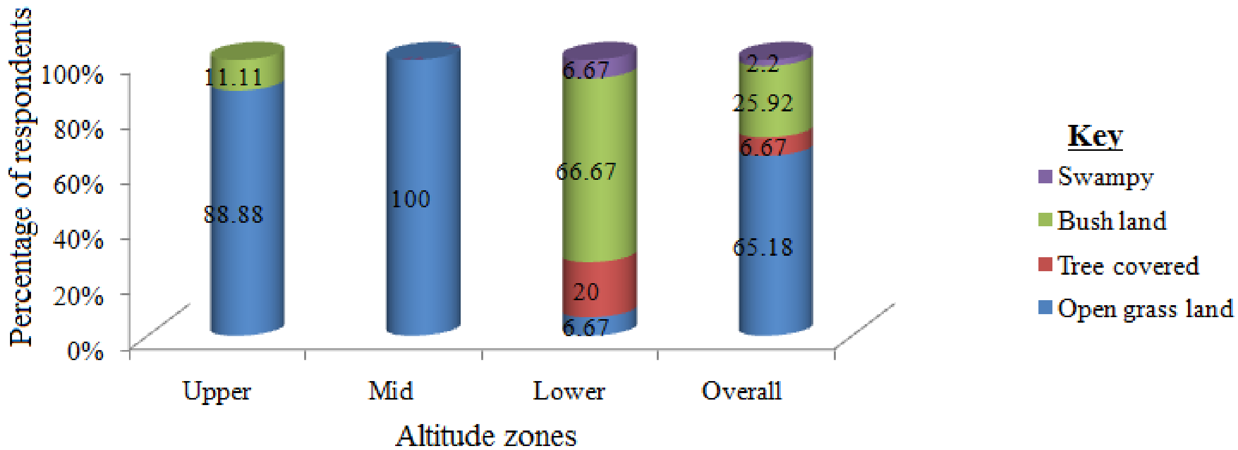

Figure 7: Types of communal grazing lands in Meta Robi district

4.8. Mineral supplementation

In the study district, (96.7%) of respondents provided salt for their animals as a mineral source (Table 15). The amount provided and the species of animals that are given this mineral need further investigation for appropriate ration formulation. Similar to this study, Belay *et al.* (2012) reported that all respondents in Dandi district, west shewa zone supplement their livestock with common salt. In Eastern zone of Tigray the provision of salt was also a recognized practice and significant number of the respondents responded that they provide salt during the wet season for their animals (Berihu *et al.*, 2014). The percentage of respondents supplying other mineral sources other than salt was 46.7, 26.7 and 10% in the upper, mid and lower altitudes, respectively. In the study district, 27.8% of the sampled households were providing natural soils as mineral sources for the animals (Table 15). Several reasons were mentioned by respondents for not providing this mineral for the animals like lack of mineral soil in the area, not knowing the mineral itself and lack of awareness of the respondents. The current result contradict with the findings of Yeshitila *et al.* (2008) where a higher percent of the respondents use naturally occurring rift valley salt lick mineral as animal feed sources in Alaba Woreda. Generally, in the study district, the percentage of farmers using other mineral sources for livestock feeding in the upper altitude was higher than in the mid and lower altitudes which might be due to the availability of the mineral sources in that particular area.

Table 15: Status of mineral supplementation in livestock feed of the study district

Provision of salts to the animal	**Upper altitude**	**Mid altitude**	**Lower altitude**	**Overall mean**
Yes	96.7%	96.7%	96.7%	96.7%
No	3.3%	3.3%	3.3%	3.3%
Other mineral sources for your animals				
Yes	46.7%	26.7%	10%	27.8%
No	53.3%	73.3%	90%	72.2%

4.9. Non-conventional feeds

In the study district, utilization of non-conventional feeds other than local alcohol waste (Atella) was very low. Based on the result of this study, these feed types were not common in upper altitude whereas only 3.3 and 6.7% of the respondents in mid and lower altitudes were using non-conventional feeds other than "*Atella*", respectively. In the study district in general, 96.7% of the respondents were not using these feeds types for their livestock. Farmers rarely use these feed types for their animals as feed source and hence, it is difficult to quantify the amount of these feed offered to the animals.

4.10. Irrigation and cropping seasons

Using different irrigation systems in crop production will not only increase crop yield but will also increase crop residue yield and animals can also get water at the nearest distance. In the upper altitude, large percentage (73.3%) of farmers use irrigation as compared to farmers in the mid (36.7%) and lower (33.3%) altitude zones (Table 16) and this is due to the availability of more water sources in the upper altitude. In general, in the study district, of the sampled households, 47.8% are using irrigation for producing food crops and animal feeds. The current finding is higher than the result of Zewdie (2010) who reported that among the respondents around Ziway area, 17% of the farmers produced vegetables with irrigation, while about 7% of the farmers produced both food crops and animal feeds. The higher percentage of respondents using irrigation in the study district indicates that there are greater water sources in the district. Generally, in Ethiopia, 11% of the water is used for livestock production of which water consumed directly by livestock is less than 2% of this figure, with most water being used for feed production (Iain, 2013).Therefore, from the current study it is possible to conclude that those farmers having irrigation facilities can produce animal feeds by irrigation if they get improved forage seeds.

Application of fertilizer and manure to the farm land for production of crop was common in the study district. Respondents in the upper and mid altitudes are applying relatively more manure than respondents in the lower altitude (Table 16) and this might be due to the presence of large number of animals in the area and availability of crop lands to the nearest distance. Generally, manure application was insignificant as compared to the number of animals owned by the respondents. This might be due to labor shortage, distance of crop land from home, lack of awareness and lack of transportation systems. The amount of fertilizer applied in the study district is ranging from 93-176.6 kg per hectare per year per household (Table 16). The amount of fertilizer applied per ha/yr/hh in lower altitude is still low as compared to upper and mid altitudes. This low application of fertilizer in lower altitude might be due to lack of capital, lack of awareness of the farmers and lack of infrastructures to transport agricultural inputs in that particular area.

Table 16: Irrigation and application of manure and fertilizer in the study district

Use of irrigation	**Upper Altitude**		**Mid altitude**		**Lower altitude**		**Overall mean**	
Yes	73.3%		36.7%		33.3%		47.8%	
No	26.7%		63.3%		66.7%		52.2%	
Kg of manure applied per hectare/yr	Mean	±SE	Mean	±SE	Mean	±SE	Mean	±SE
	483.3	±290.0	562.0	±462.7	243.7	±130.2	458.7	±376.5
Kg of fertilizer applied per hectare/yr	176.6	±34.0	161.6	±50.3	93.1	±49.5	144.3	±57.6

4.11. Livestock feeding and grazing systems

Livestock owners follow different feeding systems for efficient utilization of the available feeds. In the study district, 22.2, 37.8, 36.7, and 3.3% of the respondents fed their animals in indoor, group feeding, let to graze and tethering, respectively (Figure 8). Teshager *et al.* (2013) reported that the feeding system practiced in Ilu Aba Bora Zone was predominantly free-grazing system but for fattening beef cattle, 32.8, 0.6 and 66.7% of the respondents practiced zero, semi and free-grazing systems, respectively. In Jeldu district 94.5, 4.4 and 1.1% of the respondents practiced let to graze, cut and carry and tethering, respectively (Bedasa, 2012). As indicated above, large percentage of farmers practiced group feeding system and in that feeding system all age categories of animals fed together so that it is difficult for younger animals to satisfy their daily dry matter requirement as some of the animals can consume more than others. Similarly, the percentage of farmers allowing their animals to grazing land are also high (36.7%) and in this feeding system, the farmers could not know either the daily dry matter requirement of the animals is fulfilled. In the study district, tethering is practiced by 3.3% of the households and mostly practiced by farmers having small number of animals, labor shortage and practicing fattening of the animals.

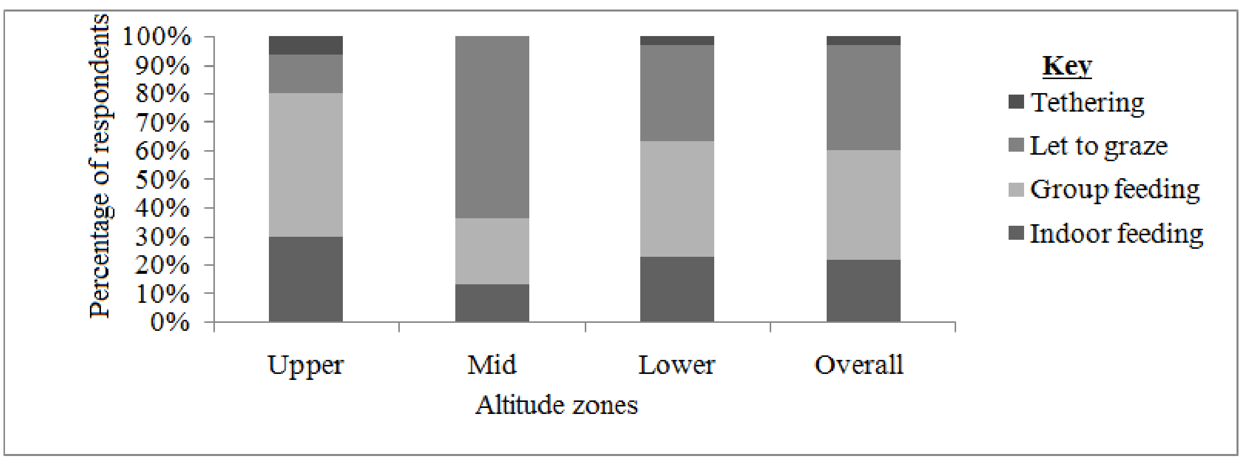

Figure 8: Livestock feeding systems in Meta Robi district

In the study district, among the grazing systems, continuous grazing, deferred grazing, and zero grazing systems were practiced by 62.2, 36.7 and 1.1%, respectively (Table 17). In the upper and mid altitudes, only continuous and differed grazing were practiced. Generally, in the study district, the percentage of respondents practicing continuous grazing were the highest (62.2%) which indicate that the grazing land could be over grazed and degraded through time unless correction measures (rotational grazing) are taken.

Table 17: Grazing systems practiced in the district

Types of grazing	Upper altitude	Mid altitude	Lower Altitude	Overall mean
Continuous	43.3%	60%	83.3%	62.2%
Differed	56.7%	40%	13.3%	36.7%
Zero grazing	-	-	3.3%	1.1%

4.12. Watering system, source of water and watering frequency

The watering systems in the upper, mid and lower altitudes were almost similar where 83.3, 100 and 80% of the respondents practicing group watering system, respectively (Table 18). In the study district, the majority (87.8%) of the respondents practiced group watering system and livestock get water from river (97.8%) and pond (2.2%). In the present study, livestock get water on average distance of 1.4 km. Getting water sources at the nearest distance can save their energy that is otherwise wasted in searching water. In the study district, 52.2% of the respondents water their animals twice a day, 38.9% once a day and 7.8% *ad libitum*. Similar to this study, Belay *et al.* (2012) reported that in Ginchi area there are three water sources and these include rivers, streams and springs and majority of the households (98%) water their animals at river. On the same report, during the dry season, when animals are herded, watering takes place almost all at rivers and streams and 80.3% of the respondents water their animals once in a day whereas 19.7% twice a day.

Table 18: Watering systems and frequency of watering in the study district

Watering system	Upper Altitude	Mid altitude	Lower altitude	Overall mean
Group watering	83.3%	100%	80%	87.8%
Individual watering	-	-	16.7%	5.6%
Both system	16.7%	-	3.3%	6.7%
Frequency of watering				
Once in a day	48.27%	3.3%	66.7%	38.9%
Twice in a day	51.72%	93.3%	13.3%	52.2%
Ad libitum	-	3.3%	20%	7.8%

4.12.1. Water related problems

In the study district, getting pure water, shortage of water supply, farness of water sources and shortage of labor to fetch water were the problems in their descending order (Table 19). In Allaba district, 66 % of the surveyed households claim shortages of water and farness of water sources from their vicinity as major water related problems (Yeshitila, 2008).

Table 19: Water related problems in Meta Robi district

Problems	Level				Rank
	1st	2nd	3rd	4th	
Shortage of pure water	44.4%	25.6%	15.6%	10%	1st
Shortage of water supply	36.7%	22.2%	13.3%	13.3%	2nd
Farness of water sources	13.3%	20%	26.7%	12.2%	3rd
Shortage of labor to fetch water	4.4%	21.1%	22.2%	20%	4th

4.13. Management of grazing lands

Managing grazing land with different management techniques like fertilizer and manure application, weeding or removal of unpalatable plants and over sowing with forage seeds are some of the techniques used to improve the productivity of grazing lands. In the study district, 33.3, 23.3 and 23.3% of the respondents reported that they had grazing land for their animal feed production in the upper, mid and lower altitudes, respectively (Table 20). Grazing land management practices were relatively less common in all areas of the district in which only 30, 20 and 20.68% of the respondents in upper, mid and lower altitudes manage their grazing land for better production, respectively (Table 20). In overall surveyed areas, 76.4% of the respondents did not manage their grazing lands but only 23.6% apply some management techniques on their grazing lands. Among the management techniques, a combination of weeding and manure application (54.54%), manure application alone (31.8%), fertilizer application (9%) and weeding alone (4.5 %) were practiced (Table 21). The current finding is in agreement with the findings of Fekede *et al*. (2013) who reported that 22.5% and 77.5% of the respondents in central highlands of Ethiopia were managing their pasture land and not managing their pasture lands, respectively. According to this investigator, 14.8% and 51.8% of the sampled households were applying fertilizer and manure, respectively. In the study district, over sowing of forage seed was uncommon. Most respondents indicated that lack of awareness mostly contributed for lack of management of their grazing lands (Table 20).

Table 20: percentage of respondents managing their grazing land in the study district

Do you have enough land for pasture production?	**Upper altitude**	**Mid altitude**	**Lower altitude**	**Overall mean**
Yes	33.3%	23.3%	23.3%	26.7%
No	66.7%	76.7%	76.7%	73.3%
Do you manage your pasture land				
Yes	30%	20%	20.68%	23.6%
No	70%	80%	79.31%	76.4%
Do you get training on feed production, conservation and utilization?				
Yes	13.3%	70%	30%	37.8%
No	86.7%	30%	70%	62.2%

In the study district, about 62.2% of the respondents had no training on livestock feed production, management, transportation, storage and utilization. The percentage of respondents getting training in mid altitude is higher (70%) than in upper (13.3%) and lower (30%) altitude and this might be due to the distance and marginality of the areas to most technologies could bring variation. The training was given by development agents, livestock experts and some NGOs. The duration of the training varies from a single day to several days with in the year.

Table 21: Grazing land management techniques in the study district

Management techniques	Upper Altitude	Mid altitude	Lower altitude	Overall Mean
Application of fertilizer	-	14.28%	16.67%	9%
Application of manure	44.44%	42.85%	-	31.81%
Removal of weeds and unpalatable plants	-	-	16.67%	4.54%
Manure application and weeding	55.55%	42.85%	66.67%	54.54%

4.14. Transportation, storage and utilization of feed

Feed transportation is one of the tasks in livestock production and management. As indicated in table 22, 68.9% of the respondents in the study district, were transporting livestock feeds to their back yard for their livestock feeding. Feed transportation in the lower altitude is very low (20%) as compared to the upper (93.3%) and mid (93.3%) altitudes. This indicates that feed transportation in the lower altitude was not a common practice and might be due to lack of awareness of the farmers, small amount of feeds or lack of transporting facilities. The common means of transportation in the study district are human power (45.07%) and donkey and horse's back (54.17%) (Table 22). In the study district, the problems raised in transporting livestock feeds were absence of transporting facilities (48.31%), lack of road access (47.19%) and bulkiness of the feed (4.4%) (Table 22). Tesfaye and Chairatanayuth (2007) also reported the major problems in collecting and storing crop residues in East shewa zone were transportation problem (35.6%), Small quantity of feeds (10.4%), far from homestead (12.3%), used for mulching (15.8%) and no feed problem (7%).

Table 22: Feed transportation mechanisms and transportation problems in Meta Robi district

Transporting mechanism	Upper	Mid	Lower	Overall
Human power	41.37%	41.37%	57.14%	45.07%
Donkey and horses (carts)	55.17%	58.62%	42.85%	54.17%
Car	3.44%	-	-	1.38%
Transporting problems				
No road access	55.17%	23.3%	63.3%	47.19%
Bulkiness	-	-	13.3%	4.49%
Absence of transport facilities	44.82%	76.7%	23.3%	48.31%

According to the respondents perceptions', feed storage during high production season was one of the coping mechanisms for feed shortage. Feed conservation in upper, mid, lower altitudes and the study district was in the order of 96.7, 96.7, 56.7 and 83.3%, respectively. In the study district, hay and crop residues were conserved by 70 and 84.4% of the respondents, respectively. In the lower altitude, significant percentage (43.3%) of respondents are not conserving feed due to several factors like inadequacy of the feed, labor shortage and lack of awareness. This implies that, in the lower altitude, livestock are more exposed to feed shortage as compared to upper and mid altitudes.

In the study district, utilization of hay and crop residue started soon after collection (47.8%), one month after collection (15.6%), two months after collection (17.8%) and stay conserved over two months (18.9%) (Table 23). Fekede *et al*. (2013) reported a similar result that farmers in the greater Addis milk shade, central highlands of Ethiopia fed stored feed to their animals soon after collection (45.5%), one month after collection (19.2%), two months after collection (24.7%) and over two months (10.3%). Utilization of conserved feed soon after collection was higher in lower altitude (66.7%) than upper (40%) and mid altitudes (36.7%) (Table 23). In the upper altitude, 36.7% of the respondents conserved feeds over two months after collection. This indicates that livestock get relatively abundant feed sources than the other two areas. About 48% of the respondents in the district start providing hay and/or crop residues soon after collection due to shortage of feed in that particular time or the respondents might not have alternative feed sources for their animals.

Table 23: Time of feeding hay and crop residues in Meta-Robi district

Feeding crop residues	Upper	Mid	Lower	Over all
Soon after collection	40%	36.7%	66.7%	47.8%
One month after	10%	13.3%	23.3%	15.6%
Two months after	13.3%	33.3%	6.7%	17.8%
Over two months	36.7%	16.7%	3.3%	18.9%

The respondents feed crop residues to their animals in different ways (Table 24) in which, 72.2% of the respondent practiced whole feeding, 16.7% chopped, 3.3% treated the feed and 7.8% of the respondents mix crop residues with other feeds. Similar to the current finding, Zewdie (2010) reported that feeding crop residues in whole (55%) and treated straw (10%) was practiced around central Rift valley. 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 24: Ways of feeding and storage systems of crop residues in Meta-Robi district

Forms of feeding crop residues	Upper Altitude	Mid altitude	Low altitude	Overall Mean
Whole	90%	46.7%	80%	72.2%
Chopped	-	46.7%	3.3%	16.7%
Treated	-	-	10%	3.3%
Mixed	10%	6.7%	6.7%	7.8%
Feed storage system				
Outside the shade	23.3%	60%	40%	41.1%
Under shade	76.7%	40%	60%	58.9%

In the study district, 41.1% of the respondents store feed outside in open air whereas 58.9% store under shed (table 24). In other study, the majority (57.8%) of the responding households indicated to store hay under open air, 29.3% under shelter shade, and 12.9% reported to use some plastic covering on the hay stored outside (Fekede *et al.*, 2013). Although, baling the hay is important for efficient utilization of feeds, all the respondents in the study district did not bale the hay and crop residues due to lack of facilities. Almost similar results was obtained by Fekede *et al.* (2013) as hay was stored in loose form by the majority (77.5%) of the respondents in central highlands of Ethiopia. As this author reported baling hay was totally uncommon in Ejere, while 31.7% of the respondents in Sululta and 35.9% of the respondents in G/Jarso reported to make baled hay.

4.15. Estimation of annual feed availability in Meta Robi district

4.15.1. Natural pasture production

In the district in general, about 12,979.5 ha of grazing lands is available (2013/14 annual report of Agricultural office of the district). Therefore, the total dry matter production from natural pasture equals to (12,979.5 ha*2 tons/ha) 25,959 tons per year. The amount of natural pasture produced by the respondents was estimated from the pasture land holding of the respondents. The pasture land holding of the total respondents in upper, mid and lower altitudes was 37.75, 42.15 and 20.25 ha, respectively. Therefore, the pasture production in the upper, mid and lower altitudes was 75.5, 84.3 and 40.5 tons/year, respectively which sums up to a total of 201 tons dry matter per year (Table 25).

Table 25: Estimated quantity of feed DM obtained from different land use types of the total respondents in the study kebele's

Land use type	Area in hectare	Conversion Factors*	Total DM Production(tones)
Grazing lands	100.5	2	201
Aftermath grazing	185.02	0.5	92.51
Forest lands	16.7	0.7	11.69
Subtotal			**305.2**

* FAO (1984) and FAO (1987)

Source: 2013/14 Annual Report of Meta-Robi district Agricultural office

4.15.2. Crop residues production

Crop residues are one of the dominant feed sources in most parts of Ethiopia especially during the dry season of the year. A total of 180,778.04 tons of crop residues were produced from different crop types in the district (Table 26). According to Tolera (1990), 10% of the crop residue loss is expected due to several factors. Therefore, 162,700.23 tons of dry matter of crop residue was obtained from the total crops produced in the district. The total crop residues produced per year in the upper, mid and lower altitudes was 243.39, 239.95 and 157.33 tons, respectively. The proportion of crop residues as animal feed (76.72%) is higher as compared to other feed types in the district, this result is in agreement with Yeshitila *et al*. (2008) who reported that of all feed resources produced, crop residues alone accounted 78.72% of livestock feed supply.

Table 26: Crop and straw yield production in Meta Robi district

Crop type	Total land plowed (ha)	Grain yield in tones	Conversion factor*	Crop residues yield in tones
Maize	4308	15,600.22	2.0	31,200.44
Sorghum	6296	17,823.4	2.5	44,558.5
Teff	9873	22,066.6	1.5	33,099.9
Wheat	9308	35,778.9	1.5	53,668.35
Barley	1129	3360.4	1.5	5040.6
Oats	105	120.5	1.7	204.85
Bean	2060	4089.6	1.2	4907.52
Pea	1926	3278.9	1.2	3934.68
Noug	1119	1040.8	4	4163.2
Total				**180,778.04**

* Kossila (1984); FAO (1987); Kossila (1988); De Leeuw *et al.* (1990)

Source: 2013/14 Annual Report of Meta-Robi district Agricultural office.

4.15.3. Crop aftermath

The contribution of crop aftermath in livestock feeding is significant especially in dry season when feed availability is limited to crop residue, hay and aftermath grazing. In the district, a total of 37,266 ha of land were covered by different crop types (Annual report of 2013/14). The conversion factor of stubble gazing into total dry matter yields is 0.5 (FAO, 1987). Therefore, 18,633 tons of feed was obtained per year from crop aftermath in the district. In the upper = 33.5; mid= 34.2 and lower= 24.91 tons of crop aftermath was produced. As indicated in table 11, these crop aftermath are majorly obtained from wheat, barley, *teff* and maize stover in the upper and mid altitudes whereas from *teff*, wheat, maize and sorghum stover in lower altitude.

4.15.4. Forest land dry matter production

In the district, the total area of land covered by forest was 6,792.75 ha (Annual report of 2013/14 of Agricultural office). The conversion factor used to get total dry matter production from forest land is 0.7 (FAO, 1987). Therefore, a total of 4,754.92 tons of feed dry matter was produced in the district. The total dry matter production from forest land in the upper altitude is (10.29 tons), mid (2.62 tons) and lower altitude is (2.1 tons). This indicates that forest land availability which could be the source of livestock feed in the upper altitude was relatively higher.

4.16. Dry matter requirement of livestock in the study district

The DM requirement is calculated based on the daily DM requirement of 250 kg dual purpose tropical cattle (an equivalent of one TLU) for maintenance requirement that needs 6.25kg/day/animal or 2281 kg/year/animal (Jahnke, 1982). Therefore, the total dry matter requirement of 170,477.8 TLU is 388,859.8 tons per year (poultry was excluded because of mono gastric nature of the animal). The annual dry matter requirement of livestock in upper altitude is (710 tons), mid (593.03 tons) and lower altitude (486.08 tons). From this result, the total dry mater requirement in the upper and mid altitudes is higher than lower altitude. This is due to relatively large number of livestock in upper and mid altitudes.

4.17. Estimated annual feed balance

The current dry matter production of feed from natural pasture grazing, crop residues, crop aftermath grazing and forest and uncultivated land in the district was 212,047.15 tons per year. The total dry matter requirement for 170,477.80 TLU (poultry is excluded because it is mono gastric) is 388,859.86 tons per year. The total dry matter produced per year in the district, can only supply the animals for 6.54 months. In the rest of the year, animals suffer from feed shortage. In upper, mid and lower altitudes, the total dry matter of feed obtained per year is 362.68, 360.71, and 224.84 tons, respectively whereas the total TLU in upper, mid and lower altitudes were 311.27, 259.99 and 213.1, respectively. Therefore, the total dry matter produced in these areas can only supply the animals for 6.12, 7.29 and 5.55 months in the year in upper, mid and lower altitudes, respectively. In Metema district, the existing feed supply on a year round basis satisfies only 72.7% of the maintenance DM requirement of livestock (Tessemma *et al.*,2003). In agreement to the current study, Bedasa (2012) also indicated that the annual dry matter production was below annual livestock requirements in the highlands of the Blue Nile basin.

4.18. Feed marketing

In the district, feed marketing along the value chain is a weak practice. Of the total respondents in the upper, mid and lower altitudes and the district in general, 40, 70, 86.7 and 65.5% replied that they did not buy agro-industrial by products and other feed types for their animals from the market. The rest of the sampled households purchase feed from farmers and these feed types were mostly natural pasture and hay but commercial feeds were not available in the area. Natural pasture, hay and local alcohol waste were marketed between farmers. In agreement to this finding, Zewdie (2010) reported that 80 and 55% of the farmers at Jimma and Sebeta, respectively, indicated that agro-industrial by products are not available sufficiently in the market. The use of agro-industrial by products such as oil seed cakes, milling by products and molasses is currently restricted to the emerging private dairy and fattening farms (Yayneshet, 2010). Molasses is supplied by the district agricultural office or the farmers purchase by themselves from Holeta town after traveling a distance of about 70 km. The farmers travel on average 9.7 km to purchase molasses or other agricultural inputs from agricultural office of the district. According to this survey result, feed processers and retailers are not present in the district so that livestock producers could not get agro-industrial by products from the market. Ninety nine percent of the households reported that agro-industrial by-products except local flour milling were not totally found in their area.

4.19. Major livestock production constraints in the district

Major livestock production constraints are presented in table 27. In the study district, livestock feed shortage was the major problem followed by animal diseases, water shortage, shortage of artificial insemination, shortage of veterinary services, shortage of extension services, shortage of market and poor genetic potential of the animals and this is in agreement with other studies (Agajie *et al.,* 2001; Dereje and Tesfaye, 2008; Zewdie, 2010; Dawit *et al*., 2013; Teshager *et al.*, 2013).

Table 27: Major livestock production constraints in Meta-Robi district

Constraints	Level								Rank
	1st	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**	
Feed shortage	37.8%	26.96%	17.86%	10.38%	6.25%	2.04%	2.35%	-	1st
Diseases	23.3%	30.33%	20.23%	15.58%	3.12%	4.08%	4.65%	-	2nd
Water shortage	7.8%	11.23%	30.95%	16.88%	6.25%	8.16%	9.30%	6.25%	3rd
Lack of AI	1.1%	4.49%	13.09%	25.97%	25.97%	12.24%	4.65%	9.37%	4th
Lack of veterinary	-	2.24%	2.38%	16.88%	28.12%	34.69%	2.35%	-	5th
Lack of extension	-	-	1.19%	1.29%	3.12%	28.57%	32.55%	37.50%	6th
Lack of market	-	8.98%	-	6.49%	12.5%	10.20%	30.23%	31.25%	7th
Poor genetic potential	30%	15.73%	14.28%	6.49%	6.25%	-	13.95%	15.62%	8th

4.20. Consequences of feed shortage

The consequences of feed shortage as listed by respondents are presented in table 28. The consequences of feed shortage in the study district are weight loss of the animals (37.8%), low milk yield (23.3%), increased mortality (13.3%), weakness of the animal (24.4%) and anoestrus (1.1%). In the lower altitude, weight loss of the animals (50%) was the highest than in the upper and mid altitudes. This indicates that feed shortage in the lower altitude was greatly affecting animal performances in the areas. In central rift valley, about 92% of the respondents indicated that weight loss and reduced milk yield were the consequences of feed shortages, while mortality due to feed shortage was reported by 43% of the respondents (Zewdie, 2010). The observation of the farmers in the study district towards anoestrus was different from the observation of farmers from Jimma and Sebeta. In the study district, only 1.1% of the respondents observed anoestrus due to feed shortage but 20 and 30% of the farmers in Jimma and Sebeta, respectively indicated absence of behavioral heat standings as the major consequence of feed shortage (Zewdie, 2010) This difference can be attributed to the difference in awareness of the farmers to animal production in different localities.

Table 28: Perceptions of the sampled households on the Consequences of feed shortage in the study district

Consequences	Upper Altitude	Mid Altitude	Lower Altitude	Overall mean
Weight loss	26.7%	36.7%	50%	37.8%
Low milk yield	36.7%	26.7%	6.7%	23.3%
Increased mortality	10%	3.3%	26.7%	13.3%
Weakness	23.3%	33.3%	16.7%	24.4%
Anoestrus	3.3%	-	-	1.1%

4.21. Strategies to overcome feed shortage during dry season

To overcome feed shortage during critical season of the year, livestock producers in all altitude zones use different strategies (Figure 10). Accordingly in the study district, 56.7% of the respondents preserve hay and crop residues during surplus production season, 20% purchase forage from local farmers, 12.2% of the farmers undertake destocking, 4.4% use improved forage,3.3% supplement their animals with different agro-industry by-products and 3.3% use fodder for their animals during feed shortage. In mid altitude most respondents (86.7%) preserve hay as a major strategy. In other district, 94.8 and 21.8% of the farmers practiced feed conservation and reduced the amount of feed offered to the livestock as major strategies to overcome feed shortage (Samuel *et al.*, 2008). In the study district, utilization of improved forages, agro-industrial by-products and fodder was insignificant as compared to other measures taken by the farmers (Figure 10). This might be due to unavailability of these feeds in the district. The current study revealed that only 3.3% of the farmers were utilizing non-conventional feeds such as vegetable refusals and local alcohol waste while about 96.7% were not using these feeds due to small amount of the feeds and lack of attention for its contribution in livestock feeding.

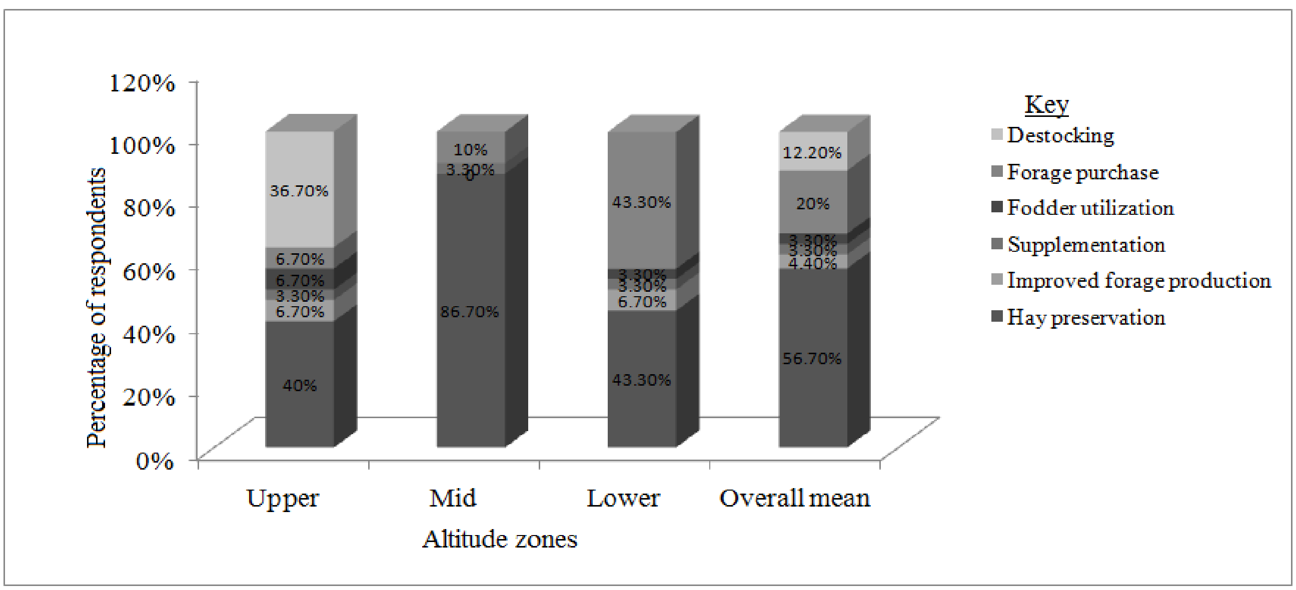

Figure 9: Strategies to overcome feed shortage in the study district

4.22. Gender participation in livestock management activities

In the study district, grazing land management was carried out by all family members (56.7%), followed by men (41.1%) (Table 29). Among the activities, weeding and fencing are common practices and these activities require high energy and that is why men were engaged mostly in these activities.

Feed collection and transportation in the study district is carried out by all family members (53.3%) followed by men alone (18.9%) and men and women (14.4%).The present finding is not in accordance with the report of Samuel *et al*. (2008) who reported that about 94.8% of the respondents in Ada'a Liben district reported that feed collection was a routine work of male.

Milking in the study district is carried out by women (71.1%) and women and girls (28.9%) (Table 29).Milk processing is also commonly carried out by women (64.4%) and women and girls (34.4%). In agreement to this study, Teshager *et al.* (2013) reported that majority (89.4%) of the respondents indicated that milking is the responsibility of women in Ilu Aba Bora zone. Milk and milk products marketing were carried out by women (74.4%) and girls (25.6%). In agreement to this finding, about 68.3% of farmers indicated that female members were responsible for marketing of animal products than male member of the family (Samuel *et al*., 2008). Generally, in the study district, milking and related activities are totally left for women and girls and this might be due to social influences.

In the study district, animal feeding was mainly carried out by all family members (56.7%) and men (16.7%). Fetching water and watering of livestock was undertaken by all family members (38.9%), women (26.7%) and women, boys and girls (17.8%).Based on farmer's opinion, 50.7% said that watering was done by the age group of 15-64 years of both sexes (Samuel *et al*., 2008).

Livestock marketing is majorly conducted by men (85.6%) and men and women (12.2%). From this result, we understand that women have less power on livestock marketing activity and this fact is well corroborated by Teshager *et al.* (2013) that 95.6% of respondents indicated that live animal marketing was carried out by the husband. In the study district, livestock herding is mostly carried out by boys (36.7%) and all family members (48.9%). In Ada'a Liben district, it was reported that male members of the family were responsible for herding (Samuel *et al*., 2008).

Barn cleaning in the district was mostly accomplished by women (27.8%) and all family members (24.4%). In other districts, about 90.3% of the farmers indicated that barn cleaning is the responsibility of female members of the family (Samuel *et al.*, 2008). Generally, in the study district, livestock related activities are mostly carried out by female members of the households. Similar to this study, the involvement of women in all cattle management activities was found to be high; however their role in decision making with regard to sale of animals was very low (Teshager *et al.*, 2013).

Table 29: Responses of the sample households regarding gender labor division in livestock management activities in the study district

Activities	**Family members**								
	Men	Women	Men and women	Men and boys	Women and girls	Women, girls and boys	Girls	Boys	All family members
Grazing land management	41.1%	2.2%	-	-	-	-	-	-	56.7%
Feed collection	18.9%	2.2%	14.4%	3.3%	-	4.4%	-	3.3%	53.3%
Animal feeding	16.7%	4.4%	7.8%	4.4%	1.1%	3.3%	-	-	56.7%
Milking	-	71.1%	-	-	28.9%	-	-	-	-
Milk processing	-	64.4%	-	-	34.4%	1.1%	-	-	-
Milk and milk product marketing	-	74.4%	-	-	-	-	25.6%	-	-
Livestock marketing	85.6%	-	12.2%	2.2%	-	-	-	-	-
Taking the animals to health center	61.1%	2.2%	32.2%	2.2%	-	-	-	-	2.2%
Fetching water and watering	1.1%	26.7%	4.4%	-	5.6%	17.8%	5.6%	-	38.9%
Animal herding	4.4%	-	3.3%	4.4%	-	2.2%	-	36.7%	48.9%
Barn cleaning	1.1%	27.8%	5.6%		14.4%	6.7%	20%		24.4%

4.23. Mineral status of soil and natural pasture of the study district

4.23.1. Macro mineral concentration in soil

The macro mineral status of soil of the study district is presented in table 30. The effect of altitude on calcium (Ca) concentration of the soil in the study area was significant ($P<0.05$) during both seasons. This indicates that calcium concentration in the soil is influenced by altitude. Relatively higher value of Ca was found in soil samples collected from lower altitude (dry=18.68 and wet=19.25 mg/kg soil) and this might be due to the high rainfall pattern in the upper and mid altitudes that cause leaching of this nutrient. The seasonal change in soil Ca concentration of the three locations was not-significant ($P>0.05$). This finding was in accordance with Lemma *et al.* (2002) who reported a non-significant effect of season on Ca concentration of soils collected from mid altitude of western Ethiopia. In the current study, the Ca concentration in all altitude is below the critical value of plants requirement (<72mg/kg) as recommended by Rhue and Kidder (1983); Pam and Brian (2007).

A non-significant effect of altitude and season ($P>0.05$) on Mg concentration was observed (Table 30). The current study shows that the Mg concentration in all altitudes during both seasons is above the critical level required for normal plant growth (<0.7 mg/kg) (Mtimuni, 1982; McDowell, 1985). This finding is in agreement with Lemma *et al.* (2002) who reported the Mg levels in soils were above the critical value and soil Mg concentration between seasons did not differ significantly ($P>0.05$).

The concentration of potassium (K) in the sampled soil during the dry season is higher than during the wet season (Table 30). This finding is in line with the earlier study by Tapiwa (2012) who reported that K concentration was higher in the dry season than in the wet season in Southern province of Zambia. This could be due to the leaching or translocation of mobile elements by rainwater to the root system during wet season (Cottenie, 1980).The effect of altitude was significant ($P<0.05$) on soil K concentration during both seasons. But season has a non-significant effect ($P>0.05$) on the concentration of K in the soil of the study area. Lemma *et al.* (2002), reported that K levels in the soils were higher than the critical level (<0.15meq/100g soil) and seasonal K concentration differences were not significant. In the current study, except the concentration of K in mid altitude during wet season, K concentration is above critical level for normal plant growth (<1.5mg/kg) as recommended by Mtimuni (1982) and McDowell (1985).

The concentration of Phosphorus (P) during the dry season was relatively higher than its concentration during the wet season (Table 30). Similar to this study, Tapiwa (2012) reported that P was higher in dry season than in wet season. This is due to leaching or translocation of P by rainwater to the root system during rainy season (Cottenie, 1980).The effect of altitude during dry season was significant (P<0.05) whereas non-significance (P>0.05) during wet season. Season had a significant (P<0.05) effect only in the upper altitude whereas in the mid and lower altitudes, it had non-significant (P>0.05) effect on the concentration of P in the soil. Phosphorus concentration in the upper altitude during wet season and mid altitude during both seasons were below the critical level of plant requirement (<10mg/kg of soil) (Table 30). This low concentration of P in soils of mid altitude (4.93-6.94 mg/kg soil) might be due to the acid nature and soil types (Nitosols) of that area that has the ability to fix P in the soil and makes P unavailable for plants.

Altitude and season did not have a significant effect (P>0.05) on Sodium (Na) concentration in soil (Table 30). In agreement to the current study, Lemma (2002) also reported a similar pattern on Na concentration in soils of Ginchi area. The concentration of Na in soil in all locations during both seasons were below the critical level required for plant (<62mg/kg soil) as recommended by Rhue and Kidder (1983) and Pam and Brian (2007).

The effect of altitude was significant (P<0.05) on the concentration of Sulphur (S) in soil during the dry season whereas non-significant (P>0.05) during wet season. The concentration of S in the soil in lower altitude was relatively lower (dry=20.59 and wet=18.36 gm/kg) as compared to upper and mid altitude. Season did not have a significant (p<0.05) effect on the concentration of S in the soil in all altitude zones.

Table 30: Mean±SE of macro minerals in soil as influenced by altitude and season in Meta Robi district (mg/kg)

Altitudes	**Ca**		**Mg**		**K**		**P**		**Na**		**S**	
	Dry season	Wet season	Dry Season	Wet Season	Dry Season	Wet Season	Dry season	Wet Season	Dry season	Wet Season	Dry season	Wet season
Upper	10.30^{bx} ±3.85	9.06^{bx} ±4.21	5.63^{ax} ±1.4	5.40^{ax} ±1.35	1.87^{bx} ±0.61	1.53^{bx} ±0.72	13.57^{abx} ±3.9	6.43^{ay} ±3.32	3.00^{ax} ±0.29	2.38^{ax} ±0.46	39.70^{abx} ±8.27	40.82^{ax} ±19.14
Mid	12.39^{abx} ±1.08	11.39^{bx} ±1.47	6.89^{ax} ±0.51	7.12^{ax} ±0.66	1.86^{bx} ±0.24	1.26^{bx} ±0.38	6.94^{bx} ±6.13	4.93^{ax} ±4.09	2.59^{ax} ±0.44	2.70^{ax} ±0.56	78.10^{ax} ±25.55	59.76^{ax} ±52.25
Lower	18.68^{ax} ±2.32	19.25^{ax} ±1.23	5.13^{ax} ±1.12	5.33^{ax} ±1.24	4.42^{ax} ±0.93	4.24^{ax} ±1.42	23.57^{ax} ±8.95	14.31^{ax} ±3.75	2.81^{ax} ±0.57	3.23^{ax} ±1.09	20.59^{bx} ±15.54	18.36^{ax} ±3.40
Critical level(mg/kg)	<72.6*		<0.7**		<1.5**		<10**		<62 *		-	

*Rhue& Kidder (1983); ** Mtimuni (1982) and McDowell (1985)

- Means with the same superscript in the same column (a, b, c) and row (x, y) are not significantly different.

- Critical level is concentrations below which samples are deficient based on plant requirements.

4.23.2. Micro mineral concentration in soil

Altitude and season did not have a significant effect ($P<0.05$) on iron (Fe) concentration in the soil of the study area. Contrary to this study, Kafeel *et al*. (2012) reported a highly significant ($p<0.001$) effect of sampling periods on Fe concentration in soil. This difference might be due to variation in soil types, organic matter contents, vegetation, rain fall and sampling month (period). Generally, Fe concentration in all study areas was above the critical level required for plant growth (2.5-4.5mg/kg) as recommended by Katyal and Randhawa (1983). This higher value (upper=105.9-116.3, mid=107.8-108.8 and lower=80.9-81.7 mg/kg) of Fe in the soil of the study area might be associated with pH and higher organic matter contents of the soil which contributed for the presence of high Fe concentration in the soil (Tisdale *et al.*, 1993).The availability of Fe and Mn in the soil decrease as soil pH increase.

Altitude and season had a non-significant ($P>0.05$) effect on the concentration of Manganese (Mn) in soil of the study district. In agreement to this, Kafeel *et al.* (2012) reported a non-significant effect of sampling periods on soil Mn concentrations. In the analyzed soil samples, the level of Mn in the soil was above the critical level for plant growth (2mg/kg) as recommended by Katyal and Randhawa (1983). The higher concentration of Mn in the soil was mostly due to the strongly acidic nature of the soil (upper=5.5 and mid=5.2). The availability of Mn in the soil decrease as soil pH increases (Tisdale *et al.*, 1993).

In this study, a non-significant effect ($P>0.05$) of altitude on Copper (Cu) concentration was observed during both seasons. Copper concentration in the study soil is higher during dry season than during wet season (Table 31) and season had a significant ($P<0.05$) effect on the concentration of Cu in upper altitude alone. In line with this finding, Tapiwa (2012) reported the concentration of Cu to be higher in the dry season than in wet season. This might be due to the high leaching and/or absorption of Cu by plants during wet season. Generally, the concentration of Cu in the sampled soil is above the critical level (0.2mg/kg) required for plant growth (Katyal and Randhawa, 1983).

The effect of altitude and season were non-significant ($P>0.05$) on the concentration of zinc (Zn) in the study soil. Znic concentration in the sampled soil was above the critical level (<0.60mg/kg) (Table 31) required for plant growth. Contrary to this study, a lower Zn concentration (0.48 to 0.89 mg/kg) in the soil was reported by Lemma and Smit (2002) around Ginchi area. These differences might be due to soil type, organic matter contents, climatic condition and rain fall of the two study sites.

Table 31: Mean±SE of micro minerals in soil as influenced by altitude and season in Meta Robi district (mg/kg)

Altitudes	**Mn**		**Fe**		**Cu**		**Zn**	
	Dry season	Wet Season	Dry Season	Wet Season	Dry Season	Wet season	Dry Season	Wet season
Upper	259.15^{ax} ±51.96	261.78^{ax} ±66.32	105.96^{ax} ±22.62	116.36^{ax} ±19.66	79.33^{ax} ±10.87	51.09^{ay} ±4.16	39.90^{ax} ±20.76	43.22^{ax} ±14.59
Mid	268.74^{ax} ±36.46	266.20^{ax} ±42.62	107.84^{ax} ±28.58	108.81^{ax} ±18.80	67.38^{ax} ±19.60	36.97^{ax} ±17.57	53.55^{ax} ±1.06	48.15^{ax} ±13.49
Lower	222.43^{ax} ±63.78	298.15^{ax} ±4.10	81.74^{ax} ±23.75	80.95^{ax} ±14.31	41.29^{ax} ±22.86	30.43^{ax} ±15.47	41.90^{ax} ±10.15	45.62^{ax} ±11.47
Critical level(mg/kg)*	2.0		2.5-4.5		0.2		<0.60	

* Katyal and Randhawa (1983)

- Means with the same superscript in the same column (a, b, c) and row (x, y) are not significantly different.

-Critical level is concentrations below which samples are deficient, based on requirements for plant growth.

4.23.3. Macro mineral concentrations in natural pasture

The macro mineral concentration of natural pasture in the study district is presented in table 32. There was a non-significant (P>0.05) effect of seasons on Calcium (Ca) content of feed in the upper and lower altitudes but a significant (P<0.05) effect at the mid altitude. This might be due to the species diversity and maturity of forages during sampling time differs in the three altitudes. Altitude had significant (P<0.05) effect on the concentration of Ca during both seasons. Almost similar result was obtained in other parts of the world where Ca contents of the pasture ranged from 1.8 to 9.8g/kg (Zafar*et al.*, 2004; Aregheore *et al.*, 2007; Reshi*et al.*, 2013). In this study, the Ca concentrations of natural pasture at the upper and mid altitudes fulfill the Ca requirement of dairy cows whereas in the lower altitude the Ca concentration in the analyzed feed was below the requirement of dairy animals (NRC, 1989). This low concentration of Ca in lower altitude might be correlated with low concentration of Ca in the analyzed soil samples.

The effect of season and altitude is non-significant (P>0.05) on magnesium (Mg) concentration of feeds of the study area (Table 32). In agreement to this, Lemma *et al.* (2002) and Lemma (2002) reported that there was non-significant difference between wet and dry seasons in Mg concentration of native pasture. Other report indicated that forages had a significant variation in the levels of Mg due to month, pasture and interaction between them (Zafar*et al.*, 2007). The variation of Mg concentration in forage of different location might be due to variation in forage species, climatic factors, soil types, seasons and rain fall pattern. In the current study, the Mg concentration of natural pasture in all locations was below the requirement of dairy cows (NRC, 1989).This low concentration of Mg in the feed may cause grass tetany in high yielding dairy cows (NRC, 2001).

A non-significant (P>0.05) effect of season and altitude on the concentration of potassium (K) in natural pasture was observed in the analyzed feed samples (Table 32). Contrary to this study, Aregheore *et al.* (2007) reported a relatively higher (13.2g/kg) K concentration for tropical forages. The concentration of K in the analyzed feeds in all locations can not satisfy K requirements of dairy animals (Table 32).

Season had a non-significant effect (P>0.05) on the concentration of Phosphorus (P) in mid and lower altitudes whereas it had a significant effect (P<0.05) at the upper altitude. Lemma (2002) also reported a non-significant effect (P>0.05) of season on the concentration of P in the pasture. Altitude had a significant effect (P<0.05) during the dry season but a non-significant effect (P>0.05) during the wet season. Others reported a higher concentration of P (1.7 to 2.7 g/kg) in forage at different regions of the world (Aregheore*et al.* 2007; Reshi*et al.* 2013). In the current study, the concentration of P in natural pasture was below the requirement of dairy animals (Table 32). In such low concentration of P in livestock feeds, supplementation of this mineral is needed because P deficiency results in reduced growth, decreased appetite, impaired reproduction and weak fragile bone (NRC, 2001).

Season had a non-significant (P>0.05) effect on the concentration of Sodium (Na) in natural pasture. Lemma and Smit (2004) also reported a non-significant (P>0.05) effect of season on Na concentration in natural pasture. Altitude had a significant effect (P<0.05) on the concentration of Na during the dry season but it had non-significant effect (P>0.05) during the wet season. The current study shows that in all locations, the concentration of Sodium (Na) in natural pasture were below the requirement of dairy animals (Table 32). To compensate this deficiency, the tradition of common salt supplementation to the feed should be encouraged.

A non-significant (P>0.05) effect of season was observed on the concentration of Sulfur (S) in the analyzed feed whereas a significant (P<0.05) effect of altitude was observed during the dry season but a non-significant (P>0.05) effect during the wet season ((Table 32). According to the current study result, the S concentration in natural pasture was above the requirement of dairy animals (Table 32).

Table 32: The effect of altitude and season on macro mineral concentration of natural pasture (Mean±SE) in the study district (g/kg DM base)

Altitudes	Ca		Mg		K		P		Na		S	
	Dry Season	Wet season	Dry season	Wet Season	Dry season	Wet Season	Dry Season	Wet Season	Dry Season	Wet Season	Dry season	Wet season
Upper	11.95[ax] ± 2.61	10.22[ax] ±1.94	0.62[ax] ±0.23	0.74[ax] ±0.16	0.33[ax] ±0.06	0.58[ax] ±0.13	0.12[bx] ±0.02	1.06[ay] ±0.13	0.52[bx] ±0.15	0.81[ax] ±0.23	10.02[ax] ±0.64	3.97[ax] ±4.39
Mid	8.95[bx] ±0.55	5.65[aby] ±1.12	0.76[ax] ±0.20	0.62[ax] ±0.10	0.57[ax] ±0.18	0.69[ax] ±0.19	0.99[ax] ±0.04	0.83[ax] ±0.42	0.78 [ax] ±0.08	0.69[ax] ±0.25	2.61[bx] ±0.77	2.48[ax] ±0.95
Lower	2.75[cx] ±0.45	3.86[bx] ±2.22	0.78[ax] ±0.23	0.69[ax] ±0.30	0.51[ax] ±0.29	0.76[ax] ±0.09	0.17[bx] ±0.04	0.56[ax] ±0.52	0.61[abx] ±0.02	0.67[ax] ±0.27	9.60[ax] ±0.22	8.09[ax] ±1.91
Recommended level of minerals for dairy animals (g/kg)												
Dry pregnant cow	3.9		1.6		6.5		2.4		1.0		0.5-5.0*	
Lactating cow	4.3-6.6		2.0-2.5		9.0-10.0		2.8-4.1		1.8			

- NRC (1989), *Neville F. Suttle (2010)
- Means with the same superscript in the same column (a, b, c) and row (x, y) are not significantly different.

4.23.4. Micro mineral concentration in natural pasture

In the current study, season had a non-significant (P>0.05) effect on the level of Mn in the upper and mid altitudes but a significant (P<0.05) effect in the lower altitude. In agreement to this study, Lemma (2002) reported a non-significant effect of season on the concentration of Mn in natural pasture. In this study, a significant effect (P<0.05) of altitude during both seasons was observed. Almost similar Mn concentration was reported by Shahjalall *et al.* (2008) in which grasses from highland, medium highland and low land agro ecologies had Mn concentration of 136.1, 108.5 and 97.8ppm, respectively. Generally, the Mn concentrations of natural pasture except in lower altitude, during wet season, were above the requirement of dairy animals (Table 33).

The current study showed a significant (P<0.05) effect of altitude on the concentration of Fe in the analyzed feeds during both seasons. Season had a significant effect (P<0.05) on Fe concentration of native pasture in upper (dry season=117.60 and wet season=259.7 mg/kg) and mid altitudes (dry season=299 and wet season=213.3 gm/kg) but a non-significant (P>0.05) effect in lower altitude (dry season=78.4 wet season=130). In other study, it was observed that the concentration of Fe in the native pasture during the dry season far exceeded wet season values, but the difference was not significant (Lemma *et al.*, 2002).Generally, the Fe concentration of natural pasture in this study were above the requirement of dairy animals (Table 33).

A non-significant (P>0.05) effect of season on Cu concentration of feed was observed in this study and a significant effects (P<0.05) of altitude on Cu concentration during dry season but non-significant (P>0.05) effect during wet season was observed. In agreement to this study, a non-significant effect of season on the concentration of Cu (dry= 8.18 and wet=19.44 gm/kg) was reported (Lemma *et al.*, 2002). Generally, the Cu concentrations of natural pasture in all locations during both seasons were above the requirement of dairy cattle (10ppm) as recommended by NRC (1989).

In this study, a non- significant (P>0.05) effect of altitude and season on the concentration of Zn was observed. In agreement to this study, Lemma *et al.* (2002) reported that the concentration of Zn in native pasture during the wet and dry seasons was not appreciably different. The concentration of Zn in the analyzed natural pasture samples in all locations during both seasons were above the requirement of dairy animals (Table 33).

4.23.5. Interaction effect of altitude and sampling season

There was a non-significant (P>0.05) interaction effect between season and altitude for most of the analyzed minerals in feed samples was observed. The interaction of season and altitude was significant (P<0.05) only for calcium, phosphorus, sulfur and iron (Appendix tables 6-15. ANOVA tables: 1-10). The interaction effect of season and altitude was non-significant (P>0.05) for all minerals analyzed in soil samples of the study district (Appendix tables 16-25. ANOVA tables: 11-20).

Table 33: The effect of altitude and season on micro mineral concentration in natural pasture (Mean±SE) in the study district (mg/kg DM base)

Altitudes	Mn		Fe		Cu		Zn	
	Dry Season	Wet Season	Dry Season	Wet Season	Dry season	Wet Season	Dry Season	Wet Season
Upper	420.82^{ax} ±226.79	435.35^{ax} ±193.71	117.60^{bx} ±17.89	259.77^{ay} ±25.94	58.92^{bx} ±4.55	126.17^{ax} ±82.58	50.82^{ax} ±22.16	52.45^{ax} ±11.06
Mid	417.72^{ax} ±136.63	369.77^{ax} ±90.30	299.00^{ax} ±23.32	213.32^{aby} ±18.56	88.95^{ax} ±2.83	84.15^{ax} ±6.22	81.27^{ax} ±15.43	58.75^{ax} ±26.72
Lower	54.10^{bx} ±11.47	29.25^{by} ±9.16	78.40^{bx} ±8.00	130.05^{bx} ±60.74	43.25^{cx} ±3.91	94.95^{ax} ±45.70	43.07^{ax} ±20.99	46.42^{ax} ±6.42
Recommended level of minerals for dairy animals								
Dry pregnant cow	40ppm		50ppm		10ppm		40ppm	
Lactating cow	40ppm		50ppm		10ppm		40ppm	
Maximum tolerable concentration	1000ppm		1000ppm		100ppm		500ppm	

- Minerals recommendation by NRC (1989)

- Means with the same superscript in the same column (a, b, c) and row (x, y) are not significantly different.

5. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1. Summary and Conclusions

An assessment of feed resources was carried out in three altitudinal zones of Meta Robi district, west shewa zone, Oromia Regional State to identify the types and sources of feeds, constraints in feed production, transportation and utilization, estimate annual feed produced, maintenance requirement, annual feed balance and determine the mineral status of natural pasture and soil samples. Secondary sources of data were collected by reviewing different documents from different district offices such as agricultural, livestock production and health and land management. A group discussion with key informants at each agro-ecology was carried out and semi-structured questionnaire was prepared to elicit information from the sample households. The district was stratified into upper, mid and lower altitudes to collect primary datas. Samples of feed and soil were collected from three altitudes during the dry and wet seasons and their mineral concentrations were determined. The survey data was analyzed with Statistical Package for Social Sciences (SPSS) while feed and soil data were analyzed with the aid of Statistical Analysis System (SAS).

The total livestock population of the district was 171,177.88 TLU of which cattle were (140,561.3 TLU), sheep (5932.1 TLU), goats (5810.5 TLU), horses (10,649.1 TLU), donkeys (5590.5 TLU), mules (413 TLU), poultry (700.08 TLU) and bee colonies (20,182). About 70% of the respondents indicated that the total number of livestock and herd composition was declining from time to time due to shortage of grazing land, shortage of livestock feeds, water and diseases outbreak.

The major feed resources in the district were natural pasture grazing (58.9%), crop residues such as wheat straw (42.4%), barley straw (30%) and hay (21.1%), local alcohol waste (18.9%) and crop aftermath (11.1%). Agro-industrial by products, non-conventional feeds and improved forage utilization is uncommon and rarely used in the study areas.

During the dry season, 90% of the respondents use crop residues followed by hay (58.8%) and stubble grazing (56.1%) as livestock feed whereas during the wet season all respondents indicated that natural pasture was the dominant livestock feed in the district. Respondents classified months of the year according to feed availability and therefore, September-November were those months when feeds are relatively available in excess. December, January, June, July and August were those months when feed is adequately available whereas, February-May were classified as months of feed shortage.

About 47% of the respondents in the study district had their own pasture land whereas 42.2% had both rented and their own pasture land. Fifty eight percent of the sampled farmers harvest hay from their own farm land, 12.2% purchased hay from others and 27.8% harvested from their own land and purchased from others. The majority (86.7%) of the respondents in the study district produce crop residues from their crop land. Improved forages was not produced by 74.4% of the respondents due to shortage of land (42.4%), shortage of forage seeds (24.3%), lack of awareness (26.4%) and unevenness of rain fall (5.6%). About 56% of the respondents purchased agro-industrial by products for their livestock whereas about 44% were not using it due to unavailability.

The availability of communal grazing land was reported by only 28.9% of the respondents in the study district. Based on the size of the land, 84.8% of the respondents indicated that the communal grazing land was decreasing through time. Respondents mentioned that, allocation of communal grazing lands to landless youths and expansion of crop lands are the major reasons for decreasing the size of communal grazing land in their area.

In the study district, continuous grazing, deferred grazing, and zero grazing systems were practiced by 62.2%, 36.7% and 1.1% of respondents, respectively. The higher percentage of respondents practicing continuous grazing (62.2%) indicated that the grazing land could be over grazed and degraded through time unless correction measures are taken. The majority (87.8%) of the respondents practiced group watering system and livestock get water from river (97.8%) and pond (2.2%). Livestock get water at an average distance of 1.4 km that can save their energy that is otherwise wasted in searching water.

About 68.9% of the respondents transported livestock feeds to their back yard for their animals. Feed transportation in the lower altitude was very low and only 20% of the respondents were transporting feeds. Hay and crop residues were conserved by 70 and 84.4% of the respondents, respectively. The utilization of hay and crop residue started soon after collection (47.8%), one month after collection (15.6%), two months after collection (17.8%) and stay conserved over two months (18.9%).

Currently, the total dry mater production from natural pasture grazing, crop residues, crop aftermath grazing and forest and uncultivated land in the district was about 212,047.15 tons per year. The total dry matter produced per year in the district, can only fed the animals for 6.54 months. In upper, mid and lower altitudes, the total dry matter produced in these areas can only feed the animals for 6.12, 7.29 and 5.55 months in the year, respectively. According to the opinion of the sampled households, in the rest of the year, animals suffer from feed shortage which resulted in weight loses, mortality and milk reduction. Even though, the available feed recourses are reported to be adequate only for about half of a year, the contribution of other feed resources like bushes and shrubs should not be ignored as this feed types were not considered during the study period due to lack of information.

Feed marketing along the value chain in the district was not practiced. Farmers mostly purchase feeds from local farmers and these feed types were mostly natural pasture and hay but commercial feeds were not available in the area. Farmers travel on average 9.7 km to purchase agricultural inputs from agricultural office of the district, this distance can contribute for low utilization of agricultural inputs including livestock feeds. Feed processers and retailers were not present in the district so that livestock producers could not easily get agro-industrial by products from market. Ninety nine percent of the sampled households observed that agro-industries except local flour milling are not totally found in their area.

The major feed production constraints in the study district were shortage of grazing lands in which only 31.6% of the land was left for grazing, absence of feed processors and retailers, absence of technologies in improved feed production and utilization, poor feeding system, poor grazing systems, poor land management and absence of awareness in livestock feed production, transportation, storage and utilization.

The concentration of most analyzed macro minerals and all micro minerals in the soil were above critical level of minerals for plant growth. Altitude had a significant effect on most macro minerals but it has non-significant effect on the concentration of micro minerals. Season had non-significance effect on mineral content of soil except for P and Cu in upper altitude. This indicates that altitude has more effect than season on the concentration of minerals in the soil.

The concentrations of most macro minerals in the feed sample were below the requirement of dairy animals except for Ca in upper and mid altitude and S in all altitudes during both seasons. Season had a non-significant ($P>0.05$) effect on the level of most macro minerals except for P in upper altitude and Ca in mid altitude. The effect of altitude was significant for most macro minerals except for Mg and K. Micro mineral concentration in natural pasture samples were above the requirement of dairy animals except for Mn in lower altitude during the wet season. Altitude had a significant ($P<0.05$) effect on the concentration of Mn and Fe during both season and Cu during dry season. Generally, more attention should be given to macro minerals during ration formulation or when supplementing the animals since season and location affect macro mineral concentration than micro minerals.

5.2. Recommendations

- The livestock population of the district needs a total of 388,859.86. tons of dry matter feed per year for maintenance requirement alone but the current production can only support for 6.54 months therefore, alternative feed production technologies such as development of improved forages, efficient feed utilization technologies (eg. provision of chopper) and natural pasture land improvement measures should be undertaken.
- Since the production, productivity, transportation, storage and utilization efficiency of the available feed was low, further research and development works should be designed to increase the production, productivity, transportation, storage and utilization efficiency of feeds.
- The contribution of improved forage in livestock feed was very low due to unavailability of the feed in the area. To alleviate this problem, nursery sites should be established in potential kebeles of the district so that dissemination and utilization of these feeds will be practical.
- During dry season, most respondents use crop residues, hay and stubble grazing for their livestock feeding but the nutritive value of such feeds in most cases was low and its quality should be assessed in the future. In addition, crop residues accounted for 76.72% of the livestock feed share in the district therefore, efficient utilization of this feed should be designed.
- To alleviate feed marketing problems that were aggravated due to absence of feed processors and retailers, the local authority should organize interested farmers or landless youths to make an association that aims to supply feeds to local farmers. Credit service should also be facilitated in order to promote those individuals or groups involved in livestock feed marketing.
- To compensate the mineral deficiency of natural pasture, improved forages with better yield and mineral contents (*Chloris gayana, Panicum coloratum, Panicum maximum and Pennisetum purpureum,*) could be alternative feed sources for livestock.

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7. APPENDICES

Appendix Table 1: Conversion factors of livestock number to Tropical Livestock Unit

Livestock species	TLU
Local oxen/bulls	1
Local cows	0.7
Local heifers	0.5
Local calves	0.2
Sheep	0.1
Goats	0.1
Horses	0.8
Donkeys	0.5
Mules	0.7
Poultry	0.01

Source: Jahnke (1982)

TLU=Total Livestock Unit.

Appendix Table 2: Land dry matter yield conversion factors

Land use	DM yield (t/ha/yr)
Natural Pasture	2.0
Aftermath	0.5
Fallow land	1.5
Forest	0.7
Wood, bush land and shrub	1.2

Source: FAO (1987)

Appendix Table 3: Mineral concentration in forages required for dairy cattle

Minerals	Dry pregnant	Lactating cow
Ca (%)	0.39	0.43-0.66
P (%)	0.24	0.28-0.41
Mg (%)	0.16	0.20-0.25
K (%)	0.65	0.90-1.00
Na (%)	0.10	0.18
S (g/kg)*	0.5 -5.0	
Fe(ppm)	50	50
Mn(ppm)	40	40
Cu(ppm)	10	10
Zn(ppm)	40	40

NRC (1989), *Neville F. Suttle (2010)

Appendix table 4: Questionnaires

1. General information

1.1. Date: ---------------------

1.2. Region: ------------------

1.3. Zone and District: ---------------------------------

1.4. PA’s/Kebele’s name-------------------------------

1.5. House holders’ name-------------------------------

1.6. Sex ----------------- age ------------

1.7. Literacy status: circle one of it,

(A) Illiterate (B) Read and write only (C) elementary (D) junior secondary (E) Secondary, (F) above secondary

2. Household characteristics

2.1. Family size

2.1.1. How many family members do you have?

A) Male---------------------- B) Female-------------------- C) Total-------------

2.1.2. Children (≤ 14 years): ----------- Adult (15-64): ----------- Dependent (≥ 65 years): ----------

2.1.3. What is your main farming activity presently? Circle one of it.

(A) Livestock production (B) Crop production (C) both (D) Others specify-------------------

2.1.4. What is your farming activity before five years?

(A)Livestock production (B)Crop production (C) Both (D) others, specify-------------------------

3. Livestock production and management

3.1. A. Livestock holding size (large ruminant).

Animal species	Local	crossbred	Total
Oxen			
Bulls			
Cows			
Heifers(>6 months)			
Calves up to 6 months of age			
Total			

3.1. B. Small ruminants, equine, poultry and Bee colonies

Type		Number
Sheep		
Goats		
Horses		
Donkey		
Mule		
Poultry		
Bee hives	modern	
	transition	
	traditional	

3.2. What are your major sources of income and estimate % contribution?

Sources of income	Tick"✓"	% contribution	Rank in terms of priority
Livestock production			
Crop production			
Trade			
Others, specify			

3.3. What are the major reasons for keeping livestock? (Rank).

Purposes	Cattle	Rank	Small Ruminant	Rank	Equine	Rank	Chicken	Rank
Draught power								
Income								
Home consumption								
Transportation								
Other (specify)								

3.4. Livestock Production constraints

Constraints	(Tick''✓'')	Rank
poor genetic potentials		
Diseases		
Feed shortage		
Water shortage		
Shortage of AI service		
Shortage of veterinary care		
Shortage of extension services		
Shortage of market for the products		
Others (specify)		

3.5: Type of feeds supplied for your animals?

Type of feeds			Tick''✓''	Rank
Pasture grazing				
Hay				
Crop residues	Wheat straw			
	Barley straw			
	Teff straw			
	Maize Stover			
	Sorghum Stover			
	Oats straw			
	Others (specify)			
Crop aftermath grazing				
Agro-industrial by products	Milling by products	wheat bran		
		wheat short		
	Oilseed cakes	noug cake		
		linseed cake,		
		sesame cake		
		cotton cake		

	Molasses		
Improved fodder			
Atela(waste of local alcohol)			
Others(specify)			

3.6. What are the sources of different feed types?

Type of feeds	Sources(Tick"✓")		
	Own produced	purchasing	both
Pasture grazing			
Grass hay			
Crop residues			
Agro industrial by products			
Improved forage			
Atela			
Others (specify)			

3.7. What are the major feed resources in dry (November- May) and wet (June-October) season? (Rank 1-6 in the order of importance).

Period	Natural pasture	Crop residues	Hay	Fodder trees	Stubble grazing	Concentrates	Others, specify
Dry season							
Wet season							

3.8. How many months in the year you get abundant feed for your livestock? -----------months

3.9. Have you ever attended training on feed production and management? A. Yes B. No

If yes, who trained you and when was the training and duration?

Trained by: ----------------------------------- Duration: ----------------

3.10. Is the number of animals increasing, decreasing or no change since the past 10 years? What is the reasons?---

4. Land holding and land use pattern of the House hold in hectare or kert.

Characteristics	Hectare	Rank
Total land owned		
Homestead		
Cropped land		
Grazing land		
Communal		
Private		
Forest & woodland		
Waste lands		
Others (Specify)		

N: B A hectare is equivalent to four kert

4.1. Do you have enough land for your livestock pasture growing (A) Yes (B) No?

If yes, how many hectares is it? ----------------ha

4.2. What type of grazing systems you are practicing?

A. Continuous grazing B. Deferred grazing C. Zero grazing (cut and carry) D. others, specify

5: Crops and crop residues

5.1: Production and utilization of crops (In reference to last year)

Crop type	Total area (*Kert)*	Yield obtained (quintal)
Maize		
Sorghum		
Teff		
Wheat		
Barley		
Oats		
Faba bean		
Field Pea		
Enset/kocho		
Nuog		
Linseed		

5.2. Do you use fertilizer or manure for the above crops production? (A) Yes (B) No

If yes, amount used per hectare or Kert

Manure----------------kg/ha

Fertilizer---------------kg/ha

5.3. Do you irrigate and produce crops? (A) Yes (B) No,

5.4. How many cropping season do you have per annum? (A) 1, (B) 2 (C) 3

5.5. When do you start feeding crop residues for your animals?

(A) Soon after collection (B) One month after (C) Two months later (D) Over two months

(E) Other (specify) ------------------------------------

5.5. How do you store hay or crop residues? (A) Stacked outside (B) stacked under shade

(C) Baled outside (D) baled under shade (E) other (specify) ------------------------------

5.6. In what form do you feed your crop residue? (A) Whole (B) chopped (C) treated

(D) Mixed with other feeds (E) other (specify) -----------------

5.6. Do you use crop residues for other purposes other than livestock feeding? A. yes B. no

If yes, for which purpose? Use other than feeding (tick''✓'')

Types of crop residues		Construction	Rank	income	Rank	fuel	Rank	Soil fertility	Rank	others	Rank
Teff straw											
Wheat straw											
Barly straw											
Oat straw											
Stover	Maize										
	Sorghum										
Pulse straw	Bean										
	Pea										
	Haricot bean										

6. Communal grazing land

6.1. Is there communal grazing land in your area? A. Yes B. No

If yes, what is the status? A. Decreasing B. Increasing C. No change

6.2. What is the type of communal grazing land in the area? (A) Open grassland

(B) Tree covered grass land (C) Bush grass land (D) Swampy (E) Other (specify).

6.3. Is the grazing resource adequate to your animals? (A) Yes (B) No

If no, what measures do you take to alleviate feed shortage? (A) Purchase concentrates (B) Purchase forage (rent grazing land) (C) Use crop residues (D) Preserve any feed during high production season (E) Undergo destocking (F) others (specify) ----------

6.4. How do you feed your animals? (A) Indoor feeding (B) Group feeding C). Let to graze (D). Tethering in a grazing land (E). Other specify--

6.5. Seasonal distribution of different feed resources

Types of feed resource	Months (Tike "✓" if applicable)											
Pasture grazing	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Stubble grazing												
Road side grazing												
Fallow land grazing												
Grass hay												
Crop residue												
Improved fodder												
Tree leaves												
Concentrate (AIBP)												
Others (Specify)												

6.6. How do you classify months of the year according to feed availability

Feed availability	Months (Tike "✓" if applicable)											
	Sep	Oct	No	Dec	Jan	Feb	Mar	Apr	Ma	Jun	Jul	Au
Excess												
Adequate												
Shortage												

6.7. Do you apply any management technique to improve productivity of your pasture land?

(A) Yes (B) No

If yes, what management technique do you apply?

Management technique	Tick''✓''
Application of fertilizer	
Application of manure	
Over sowing of forage legume seeds	
Removal of weeds and unpalatable plants	
Others (specify)	

6.8. If not applying any management techniques why? ---

7. Improved forage and pasture crops

7.1. Do you have improved forages, shrub or trees for your animal feeding? (A) Yes (B) No

If yes, is it planted by you or natural grown? (A) Planted by me (B) Existing naturally (C) I do not know

Local/ scientific name of improved forages, trees and shrubs

S.No	Name of the improved grasses, trees or shrubs
1	
2	
3	
4	

7.2. Did you saw any forage crop last year or this year? (A) yes (B)No

If yes, name the forage and in how many hectare of land?

1---in --------ha

2---in --------ha

3---in --------ha

7.3. If you do not plant improved pasture, what is the reason?

(A) Shortage of land (B) Shortage of forage seed (C) Unevenness of rainfall (D) I am not aware about it (E) Not interested in it (F) other (specify) --------------------------------

8. Non-conventional feed resources given to livestock in the area? (Eg. House wastes, banana leaves, brewery waste).

8.1. Do you use any non-conventional feed resources? (A) Yes (B) No

If yes what is the name of the feed?

1 ------------------------------ 2. ------------------------- 3. -------------------------------

9. Feed collection, transportation and storage

9.1. How do you decide the appropriate time for cutting to make hay? Suggest your own experience---

9.2. Do you conserve/store Feeds for your animals? (A) Yes (B) No

If yes, which type of feed do you conserve/store?

Types of feed	Tick one or more ‘’✓’’	Rank
Hay		
Crop residues		
Improved forage		
Other(specify)		

9.3. If you are not preserving hay either from pasture or crop residues, what are the reasons?

(A) Inadequacy (B) Labor shortage (C) lack of awareness (D) Other, specify

9.4. What considerations do you make in selecting the crops you grow in relation to animal feeds? (A) Select crop verities that yield higher residues in both quality and quantity

(A) Yes (B) No,

If yes which crop residue is most preferred by your livestock? Rank them.

1st---------------------- 2nd ------------------------- 3rd -------------------------

9.5. What are the consequences of the feed shortage? (A) Weight loss (B) Milk yield reduction (C) Increased mortality (D) Abortion (E) Weakness (F) Anoestrus (G) others, specify

9.6. Measures taken to alleviate feed shortage (A) Feed preservation as hay (B) Use of improved forage production (C) Concentrate supplementation (D) Fodder utilization (E) Forage purchase (F) Destocking (g) None (H) others, specify-------------------------------

9.7. Do you transport feeds in your area? (A) Yes (B) No

9.8. If yes what is the transporting system for the different feed categories

(A) Human back (B) Donkey or horse (C) Car (D) Others (Specify) ------------------

9.9. What problems do you have in transporting livestock feeds? (A) No road access (B) Bulkiness of the feed (C) Absence of transporting facilities (D) Others, Specify

10. Mineral supplementation

10.1. Do you supply salt for your animals? (A) Yes (B) No

If no, why you do not supply? --

10.2. Do you supply any mineral supplements other than salt for your animals (Eg: natural mineral soil)? (A) Yes (B) No If no why? ---

11. Feed marketing

11.1. Do you purchase fed for your animals? (A).Yes (B) No

If yes, which types of feed you purchase?

<table>
<tr><th colspan="3">Type of feed purchased</th><th>Tick’’✓’’</th><th>Where do you purchase? / source.</th></tr>
<tr><td colspan="3">Grass hay</td><td></td><td></td></tr>
<tr><td rowspan="5">Crop residues</td><td colspan="2">Wheat straw</td><td></td><td></td></tr>
<tr><td colspan="2">Barley straw</td><td></td><td></td></tr>
<tr><td colspan="2">Teff straw</td><td></td><td></td></tr>
<tr><td colspan="2">Maize Stover</td><td></td><td></td></tr>
<tr><td colspan="2">Sorghum Stover</td><td></td><td></td></tr>
<tr><td rowspan="7">Agro industrial by products</td><td rowspan="2">Milling by products</td><td>wheat bran</td><td></td><td></td></tr>
<tr><td>wheat short</td><td></td><td></td></tr>
<tr><td rowspan="4">Oilseed cakes</td><td>noug cake</td><td></td><td></td></tr>
<tr><td>linseed cake</td><td></td><td></td></tr>
<tr><td>sesame cake</td><td></td><td></td></tr>
<tr><td>cotton cake</td><td></td><td></td></tr>
<tr><td colspan="2">Molasses</td><td></td><td></td></tr>
<tr><td colspan="3">Balanced ration</td><td></td><td></td></tr>
</table>

11.2. Is there any ago processing industries in your area? (A) Yes (B) No

If yes, which type is available?

Type of agro industry	Tick’’✓’’	Distance in Km from farm gate
Flour mills		
Oil mills		
Breweries		
Sugarcane factories		
Feed processors		

11.3. If there are no agro industries in your area where do you get those by products? (Eg: Wheat bran, wheat shout, noug, linseed, cotton and sesame cakes)

Supplier of the products	Tick''✓''	Distance in Km from farm gate
Local retail shops		
Dairy cooperatives/union		
Office of agriculture		
Others (specify)		

12. Water sources and watering management

12.1. What sources of water are available for your animals?

Sources of water	Tick ''✓''	Distance from home (Km)
River		
Spring		
Pond		
Pipe water		
Others (specify)		

12.2. What type of watering system you are following while watering your animals?

(A) Group watering (B) Individual watering (C) Both

12.3. What are the major problems you are facing related to watering of your animals?

Problems	Tick''✓''	Rank
Shortage of water supply		
Source of water is far		
Shortage of labor to fetch water		
The water is not pure		
Others (specify)		

12.4. How frequently cattle are watered during dry season? (A) Once in a day (B) Twice in a day (C) A*d libitum* (D) Once in two days (E) Once in three days (F) other (specify) -------

13. Gender participation in animal and feed production and management

13.1. Who is responsible for the management of grazing lands for better production? (Eg. Weeding, fencing). (A) Men (B) Women (C) Children (D) All family members

13.2. Division of labor in animal production and management. Tike “✓” if applicable

Activities	Men	Women	Boys	Girls
Milking				
Feeding				
Feed collection, transportation and storage				
Taking the animals to health center				
Fetching water and watering				
Livestock marketing				
Milk processing				
Milk and milk product marketing				
Herding				
Burn cleaning				
Housing(construction)				

Appendix table 5: Questionnaires for Group discussion

A. Farmers

1. What are the major livestock production constraints in your area? (Rank them)

2. What problems are you facing in livestock feed production, management, transportation and storage? (Rank them)

a. Natural Pasture

b. Crop residue

c. Agro industrial By-products

d. Others

3. What problems did you observe in improved forage production and management?

4. Types of ownership of grazing lands? Which is most abundant? (For instance communal, private and sub-divisions of them if they exist)

5. Their systems of grazing for each type (communal, private and etc)

6. What problems did you encounter in gazing land utilization and management of different ownership types? (Rank them)

7. What administrative measures do you follow to solve problem related to grazing land? (Rank them)

8. Do you get extension services on animal feeds production, management, utilization and improvements?

9. How frequent do you get extension services on different kinds of feed resources (Consider each feed category separately?

a. Natural Pasture

b. Crop residue

c. Agro industrial Byproducts

d. Others

10. Are you satisfied with the services you are getting from extension workers? (Eg: Training)

B. Feed retailers and processors

1. Are there other feed retailers and processors in your PA? If not why?

2. As feed retailer or processers what problems did you observe in feed marketing? (Rank them).

3. What solutions you recommend to solve those problems?

4. Do you supply enough livestock feeds for the consumers? If not what are the reasons?

5. What problems did you face in feed transportation and processing?

6. What is the demand of livestock feeds look like in your area?

C. Extension agent /Livestock expert

1. As an extension agent, what are the major problems in animal feed production, management, transportation, storage and utilization?

a. Natural Pasture

b. Crop residue

c. Agro industrial Byproducts

d. Others

2. Are there any other organizations in your area working on animal feeds production, management and marketing? If any who are they? What are they doing?

3. Did you get trainings on animal feed management? Who gave you the training? And are you satisfied with the training?

4. What limitations you observed of farmers concerning feed production, management, transportation, storage and utilization?

a. Natural Pasture

b. Crop residue

c. Agro industrial Byproducts

d. Others

5. How many improved forage species are found in your area? What was the source? How is their use by the communities? If low why?

6. What to do to improve livestock feed shortage?

Appendix table 6: ANOVA Table 1. Analysis of variance for interaction effect of altitude and season (Ca in pasture)
Dependent Variable: Ca.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Altitude	2	242.2415186	121.1207593	47.88	<.0001
Season	1	10.2338160	10.2338160	4.05	0.0595
Altitude*Season	2	19.9358168	9.9679084	3.94	0.0381

Appendix table 7: ANOVA. Table 2. Analysis of variance for interaction effect of altitude and season (Mg in pasture)
Dependent Variable: Mg.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Altitude	2	0.01314608	0.00657304	0.14	0.8707
Season	1	0.00756150	0.00756150	0.16	0.6934
Altitude*Season	2	0.07248325	0.03624163	0.77	0.4779

Appendix table 8: ANOVA Table 3. Analysis of variance for interaction effect of altitude and season (K in pasture)
Dependent Variable: K.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Altitude	2	0.16687225	0.08343612	2.58	0.1038
Season	1	0.25626667	0.25626667	7.91	0.0115
Altitude*Season	2	0.02581758	0.01290879	0.40	0.6770

Appendix table 9: ANOVA Table 4. Analysis of variance for interaction effect of altitude and season (P in pasture)
Dependent Variable: P.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Altitude	2	1.20218408	0.60109204	7.52	0.0042
Season	1	0.89938817	0.89938817	11.26	0.0035
Altitude*Season	2	1.22215158	0.61107579	7.65	0.0039

Appendix table 10: ANOVA Table 5. Analysis of variance for interaction effect of altitude and season (Na in pasture)
Dependent Variable: Na.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Altitude	2	0.03813233	0.01906617	0.50	0.6133
Season	1	0.04420417	0.04420417	1.17	0.2947
Altitude*Season	2	0.15092133	0.07546067	1.99	0.1658

Appendix table 11: ANOVA Table 6. Analysis of variance for interaction effect of altitude and season (S in pasture)
Dependent Variable: S.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Altitude	2	167.9005646	83.9502823	20.20	<.0001
Season	1	39.2653002	39.2653002	9.45	0.0065
Altitude*Season	2	38.3319086	19.1659543	4.61	0.0242

Appendix table 12: ANOVA Table 7. Analysis of variance for interaction effect of altitude and season (Mn in pasture)
Dependent Variable: Mn.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Altitude	2	731867.9725	365933.9862	18.93	<.0001
Season	1	2263.9837	2263.9837	0.12	0.7362
Altitude*Season	2	3991.4175	1995.7087	0.10	0.9025

Appendix table 13: ANOVA Table 8. Analysis of variance for interaction effect of altitude and season (Fe in pasture)
Dependent Variable: Fe.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Altitude	2	92724.78250	46362.39125	49.35	<.0001
Season	1	7797.61500	7797.61500	8.30	0.0099
Altitude*Season	2	52645.70250	26322.85125	28.02	<.0001

Appendix table 14: ANOVA Table 9. Analysis of variance for interaction effect of altitude and season (Cu in pasture)
Dependent Variable: Cu.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Altitude	2	2374.413333	1187.206667	0.79	0.4680
Season	1	8686.815000	8686.815000	5.80	0.0270
Altitude*Season	2	5750.170000	2875.085000	1.92	0.1757

Appendix table 15: ANOVA Table 10. Analysis of variance for interaction effect of altitude and season (Zn in pasture)
Dependent Variable: Zn.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Altitude	2	2728.725833	1364.362917	4.00	0.0366
Season	1	205.335000	205.335000	0.60	0.4481
Altitude*Season	2	837.142500	418.571250	1.23	0.3168

Appendix table 16: ANOVA Table 11. Analysis of variance for interaction effect of altitude and season (Ca in soil)
Dependent Variable: Ca.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Altitude	2	376.3701083	188.1850542	26.36	<.0001
Season	1	1.8260167	1.8260167	0.26	0.6192
Altitude*Season	2	3.8791083	1.9395542	0.27	0.7652

Appendix table 17: ANOVA. Table 12. Analysis of variance for interaction effect of altitude and season (Mg in soil)
Dependent Variable: Mg.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Altitude	2	14.54425833	7.27212917	5.78	0.0115
Season	1	0.02281667	0.02281667	0.02	0.8944
Altitude*Season	2	0.26925833	0.13462917	0.11	0.8991

Appendix table 18: ANOVA Table 13. Analysis of variance for interaction effect of altitude and season (K in soil)
Dependent Variable: K.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Altitude	2	38.92523333	19.46261667	29.14	<.0001
Season	1	0.82881667	0.82881667	1.24	0.2800
Altitude*Season	2	0.17213333	0.08606667	0.13	0.8799

Appendix table 19: ANOVA Table 14. Analysis of variance for interaction effect of altitude and season (P in soil)
Dependent Variable: P.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Altitude	2	708.2076000	354.1038000	12.10	0.0005
Season	1	226.3204167	226.3204167	7.73	0.0123
Altitude*Season	2	55.5825333	27.7912667	0.95	0.4054

Appendix table 20: ANOVA Table 15. Analysis of variance for interaction effect of altitude and season (Na in soil)
Dependent Variable: Na.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Altitude	2	0.66703333	0.33351667	0.85	0.4452
Season	1	0.00481667	0.00481667	0.01	0.9132
Altitude*Season	2	1.13493333	0.56746667	1.44	0.2628

Appendix table 21: ANOVA Table 16. Analysis of variance for interaction effect of altitude and season (S in soil)
Dependent Variable: S.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Altitude	2	9868.116608	4934.058304	7.27	0.0048
Season	1	252.072017	252.072017	0.37	0.5498
Altitude*Season	2	432.955158	216.477579	0.32	0.7309

Appendix table 22: ANOVA Table 17. Analysis of variance for interaction effect of altitude and season (Mn in soil)
Dependent Variable: Mn.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Altitude	2	268.499233	134.249617	0.06	0.9455
Season	1	3830.426667	3830.426667	1.60	0.2215
Altitude*Season	2	7661.883633	3830.941817	1.60	0.2286

Appendix table 23: ANOVA Table 18. Analysis of variance for interaction effect of altitude and season (Fe in soil)
Dependent Variable: Fe.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Altitude	2	4333.044933	2166.522467	4.58	0.0247
Season	1	74.553750	74.553750	0.16	0.6961
Altitude*Season	2	145.100800	72.550400	0.15	0.8590

Appendix table 24: ANOVA Table 19. Analysis of variance for interaction effect of altitude and season (Cu in soil)
Dependent Variable: Cu.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Altitude	2	3459.425700	1729.712850	6.52	0.0074
Season	1	3222.020267	3222.020267	12.15	0.0026
Altitude*Season	2	459.563433	229.781717	0.87	0.4373

Appendix table 25: ANOVA Table 20. Analysis of variance for interaction effect of altitude and season (Zn in soil)
Dependent Variable: Zn.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Altitude	2	377.0992000	188.5496000	1.07	0.3654
Season	1	1.7930667	1.7930667	0.01	0.9209
Altitude*Season	2	106.2485333	53.1242667	0.30	0.7444